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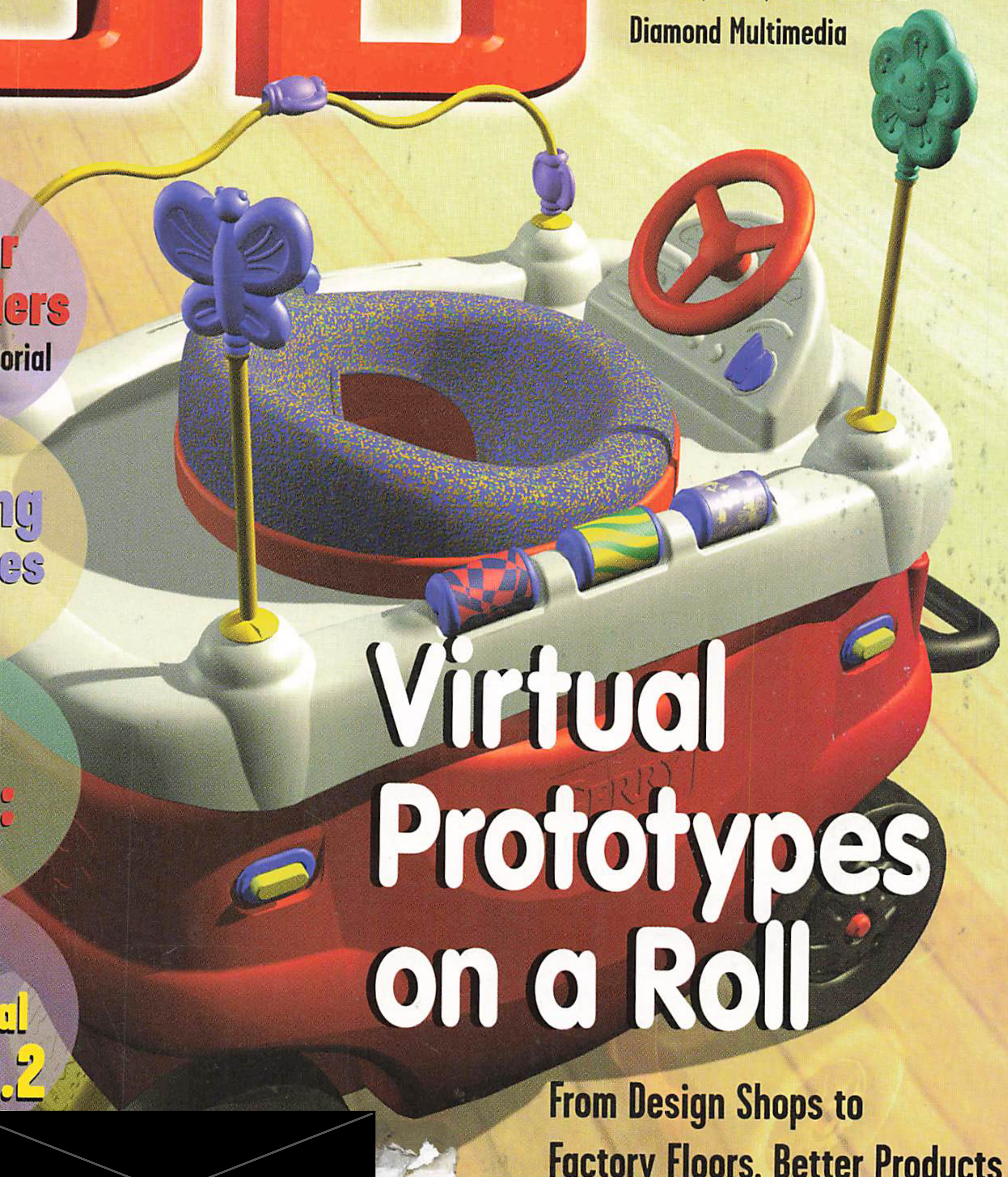
ADVANCED GRAPHICS & ANIMATION

JULY 2000

# 3D

## Graphics Card Roundup

Testing the best from 3Dlabs, ELSA, Intense3D & Diamond Multimedia



## Write Your Own Shaders

A RenderMan Tutorial

## Mastering Walk Cycles

## Digital Mattes:

Just Map It

REVIEWED:

**Nothing Real Shake 2.2**

# Virtual Prototypes on a Roll

From Design Shops to Factory Floors, Better Products Start with Virtual Prototypes

[redacted]

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Vol. 6, No. 7

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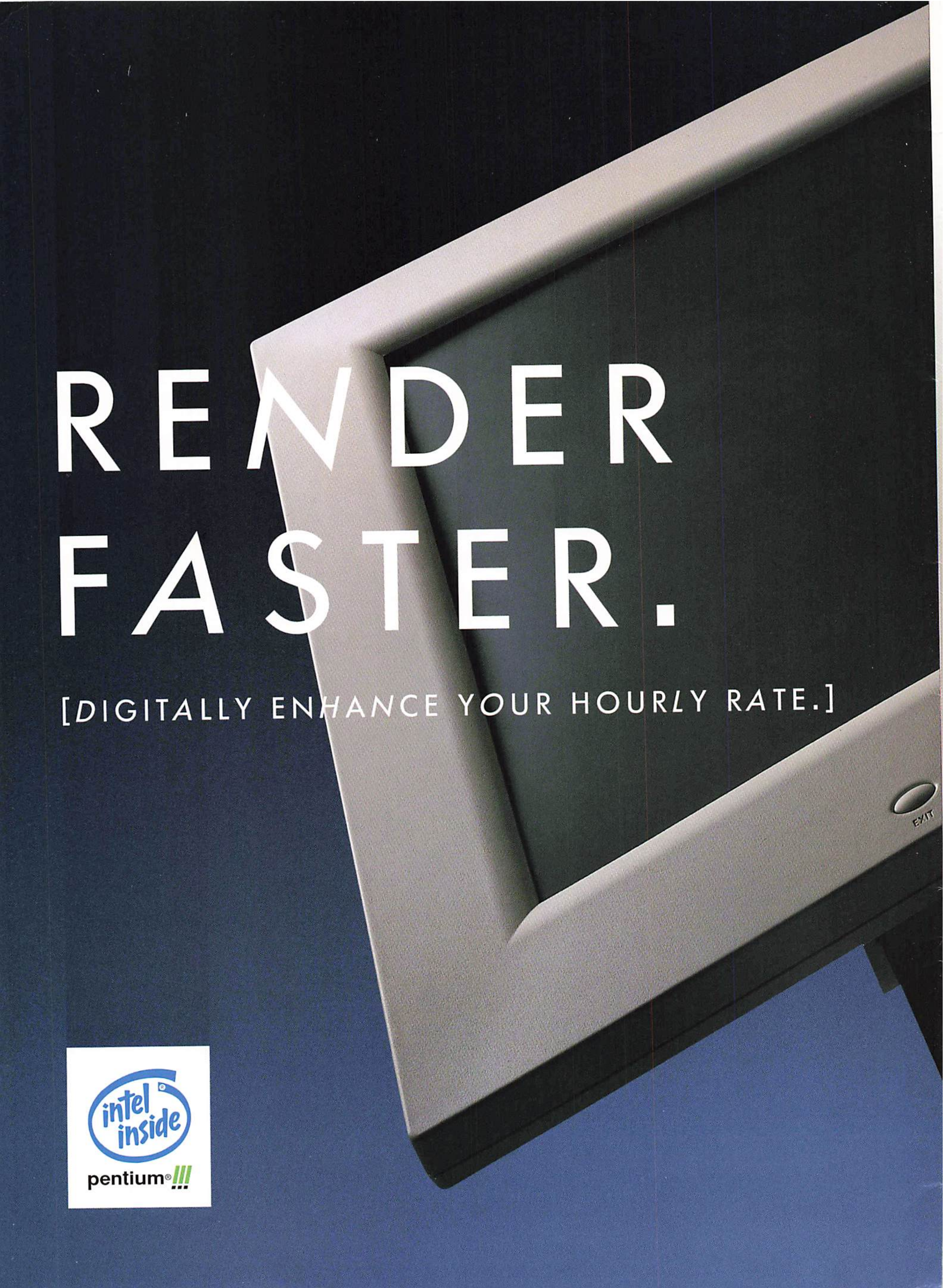
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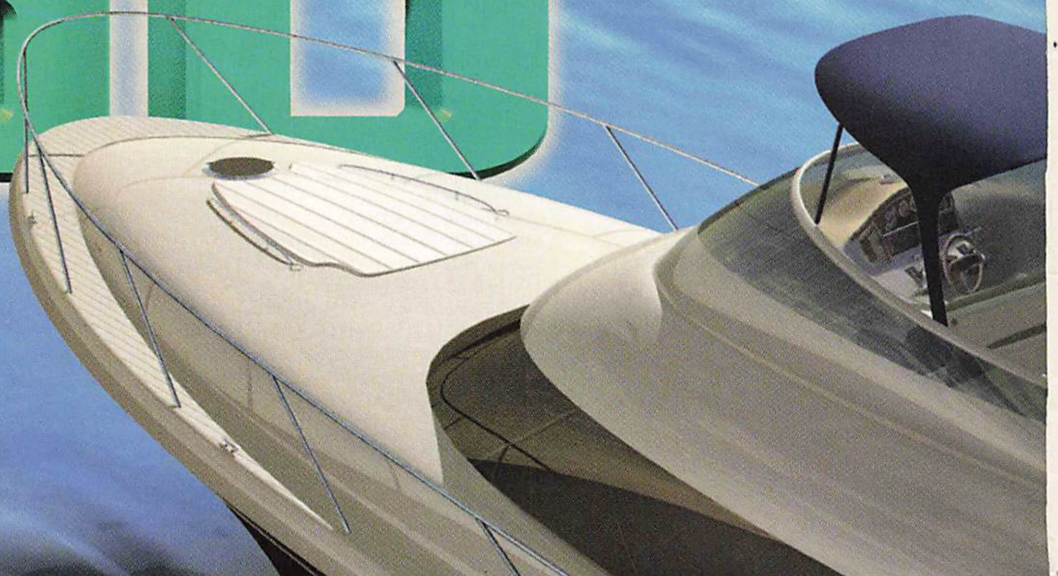
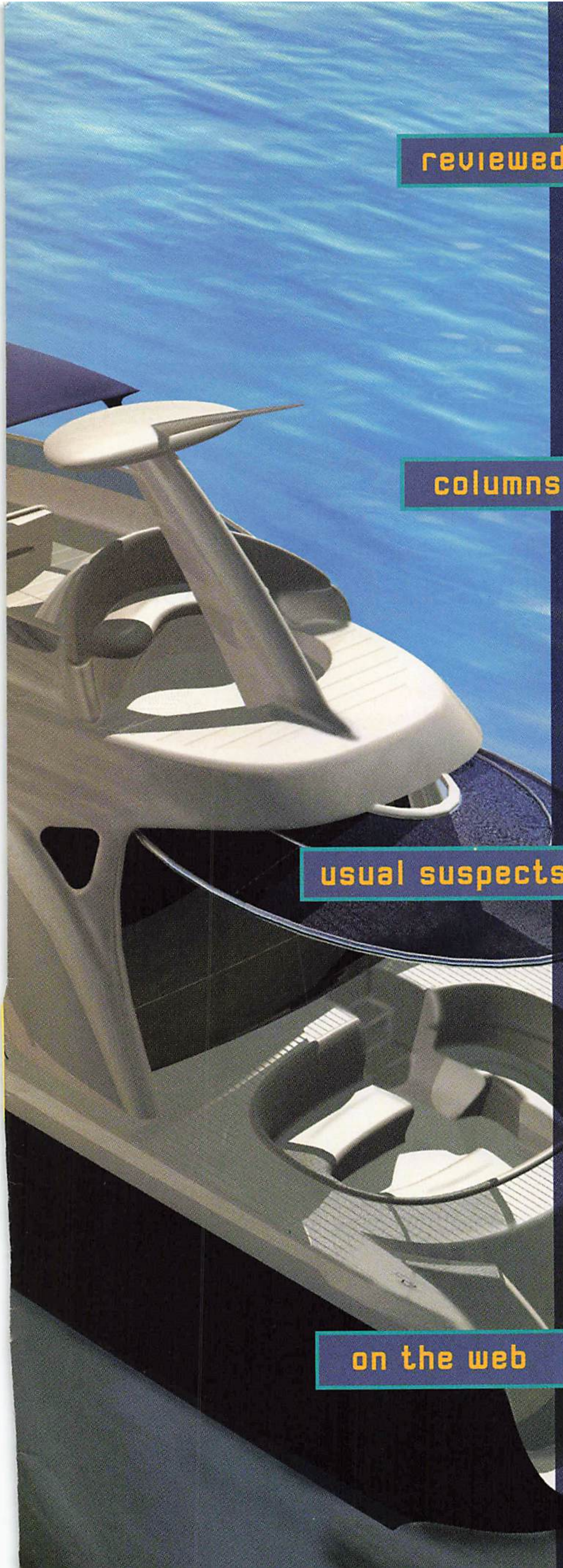
# 3D July 2000



## features

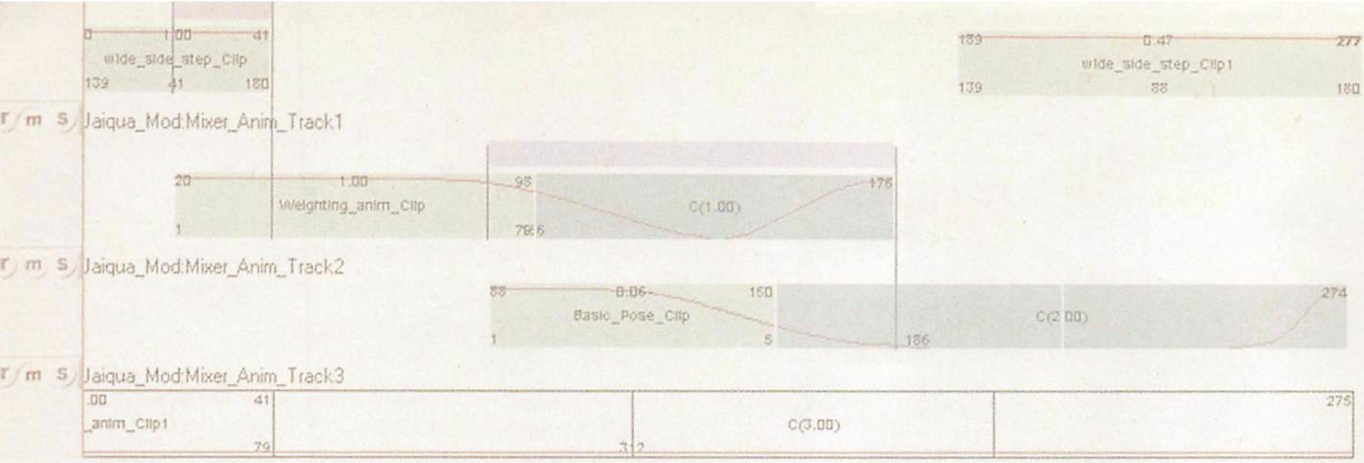


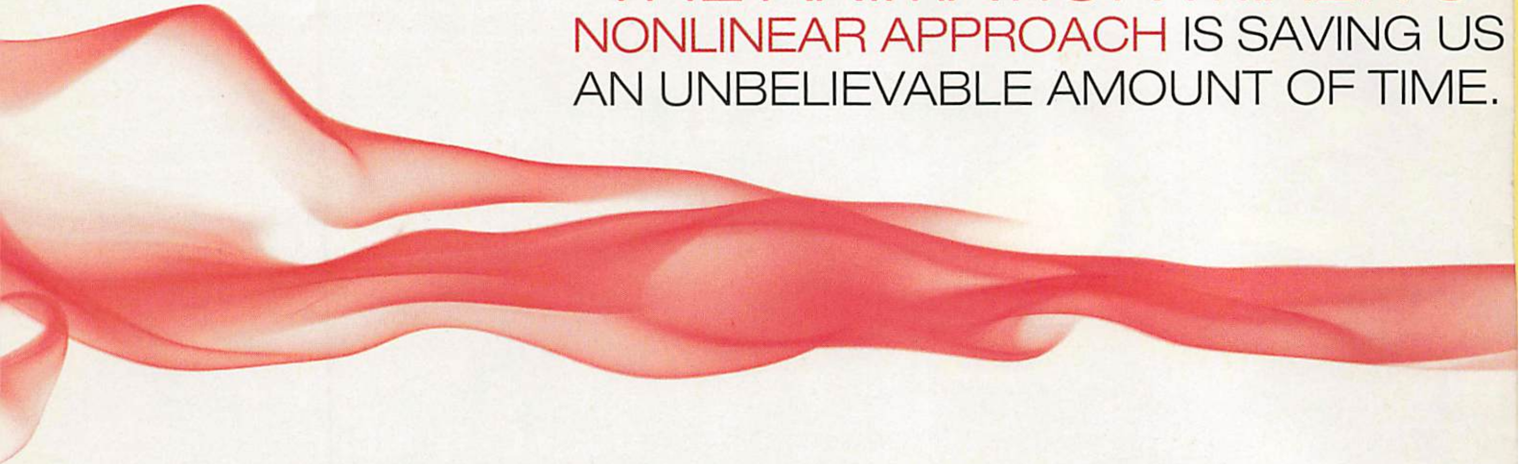


## on the web

Download this month's hands-on RenderMan tutorial, complete with all code listings, at www.3Dgate.com.

Cover image and table of contents image courtesy of Brooks Stevens Design.



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**—PETER OBERDORFER, CREATIVE DIRECTOR, GIANT KILLER ROBOTS**



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**POSTMASTER:** Send address changes to: *3D*, Circulation Dept., PO Box 5031, Brentwood, TN 37204-5301.

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CMP


## OUT OF MY M!ND

# Evolution of 3D

In November 1995, the premier issue of *3D* magazine (known then as *3D Design*) spoke of a new revolution. The entrance of Windows NT workstations into the graphics and broadcasting markets gave graphics professionals—who envied the capabilities of expensive UNIX workstations—their own solution. NT workstations would give graphics professionals a cost-effective means of creating 3D content. And a magazine was born to serve them.

*3D*'s editors set about ushering this new technology into the hands of graphics professionals across many different markets, including CAD, game development, film, video, visualization, and yes, in 1995 premature ideas were circulating about a new three-dimensional World Wide Web.

In the years since, we've seen radical changes in technology, and *3D* led this change with evolving coverage that focused on the rapidly growing abilities of 3D technology and the astounding work created by its users. Through the Wired for 3D awards, our editors congratulated the most outstanding achievements by vendors each year, and through the much-celebrated Big Kahuna Awards, we celebrated the breathtaking achievements of the artists who brought technology to life.

In the past 12 months, we've continued to see the 3D market mature and evolve. 3D is more and more becoming the standard, and less and less the strange child that many belittled out of fear or lack of understanding. For example, in 1995 CAD designers were hardly interested in exploring 3D technology, let alone using it in their work. Today CAD designers use 3D in ever-increasing numbers to lower costs and production time and to improve their designs. The same holds true in the game-development, film, and video industries. You'd be hard-pressed to find a professional product in any of these markets that doesn't include the use of 3D.

I'll digress for one moment to quote a well-known innovator: "For every action, there is an equal and opposite reaction," Sir Isaac Newton's third law of motion. As 3D proliferates in these markets, professionals require information on 3D technology in growing numbers. As a result, market-based magazines have responded with increased coverage and specific applications for their industry. At CMP Media, our sister publications *Game Developer*, *DV*, and *CADENCE* magazines have increased their coverage of 3D and will continue to do so as more of their readers utilize 3D technology. This has caused us to re-examine our strategy of how best to serve our readers; the answer is to evolve.

You hold in your hands the final issue of *3D* magazine. After publishing the July issue, some of *3D*'s team members and its awesome writers are moving on to new opportunities, many within the CMP family. Our readers' information needs will be served through expanding coverage in 3Dgate (our online community), *Game Developer*, *DV*, and *CADENCE*. To serve the still-evolving web 3D technology, CMP will continue to invest in and grow our 3Dgate.com web site. With more than 100,000 visits per month, 3Dgate is the ideal platform to serve the rapidly evolving web graphics marketplace.

I'd be lying if I didn't admit there's sadness mixed with excitement as we move on. We'll all miss the people we've met and the teams we've worked with. 3D technology has evolved. Its acceptance in many markets is firmly established, so with our sadness is a degree of satisfaction in having been a part of driving that acceptance.

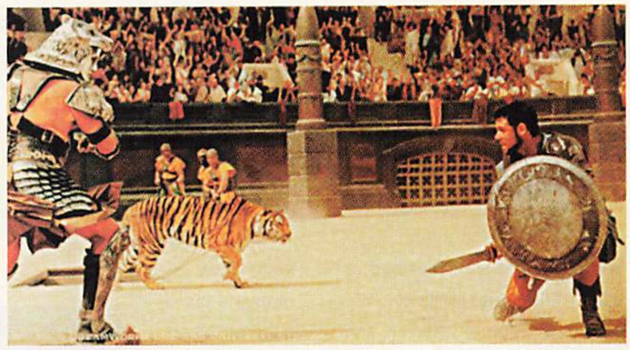
In the future, we hope you'll continue to grow your 3D skills and CMP's media products will continue to serve as inspiration. Thank you!

Bob Melk, publisher

BY MATTHEW HOOVER

# 3D at the Movies & in Person

- **Summer blockbusters are, as usual, full of 3D effects**
- **3D Expo makes the virtual into reality**
- **Plus SIGGRAPH time & other news**



**Mill Film of London generated the crowds in *Gladiator* with mocap data and 3D models.**

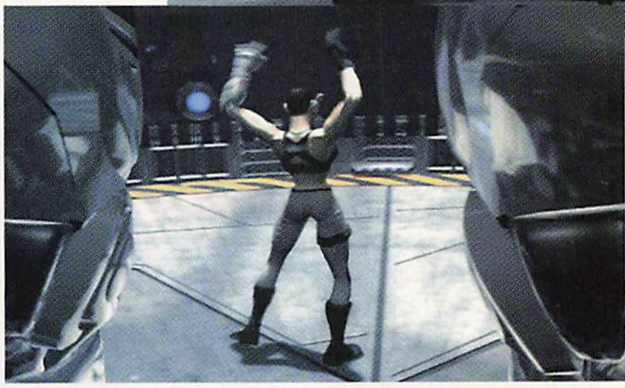
**Reality Check Studios of Hollywood created the dolphin-shaped Wake Angels for *Titan AE.***

It's summertime, and that means box-office blockbuster movie time for Hollywood. Disney's *Dinosaur* is raking in the dough with 3D dinosaurs composited onto touched-up live-action backgrounds. The prehistoric beasts were reportedly modeled from scratch with Alias PowerAnimator (Maya was in beta when the project began), Maya, Softimage 3D, and NewTek LightWave. Facial animation, skin, and muscle control was done with Maya, including lots of MEL scripts and plug-ins, and rendering was done with Pixar RenderMan and proprietary Disney software. Disney is talking about a record $200-some million budget for the movie—the price actually includes the entire Disney Secret Lab facility it built, from which *Dinosaur* is the first product. Disney has never had a full digital animation studio until now. Look for more big 3D animation from Disney in the coming months and years.

**Crowds of Gladiators** *Gladiator* from DreamWorks is another big hit with audiences, and even though it features human stars it still has plenty of 3D effects—crowds, for instance. Mill Film (www.millfilm.com) produced hundreds of effects and tapped into AudioMotion's (www.audiomotion.com) services to capture motion for thousands of CG characters to fill large crowd scenes in the Roman Empire. When planning *Gladiator's* post effects, Mill Film had a variety of options available; 3D models recreated sections of buildings that no longer existed (the Colosseum, for example), and the traditional way to populate these would be filming 2D plates and "pasting" them into the 3D sections with traditional compositing techniques. However, this limits your freedom in areas such as how the characters can be placed with respect to camera angles. 3D figures, however, can be placed and viewed from any angle. Mill used motion capture with Vicon 8 cameras. About 180 minutes of multicharacter motion data were captured, which took three days to complete using a 17-camera Vicon 8 system. Six lycra-clad actors each had 36 markers attached. Many sequences used multiple actors to ensure that the interaction between characters onscreen was maintained. Data quality was ensured by using the 17-camera system, even when the actors were in close proximity to each other—not an easy thing to achieve with alternative equipment. Mill Film took the data from AudioMotion in the Vicon-native binary data format and mapped it to characters in SoftImage 3D 3.8 using its internal constraint mechanisms. The constraints were developed by Ben Morris, who was also responsible for directing the actors at AudioMotion's Banbury, U.K.–based studio.

**A Titan Job** Reality Check Studios (www.realityx.com), a 3D animation production company based in Hollywood, completed its first feature film CG project as part of Fox's *Titan AE*, which combines 2D and 3D animation. Kory Jones, cofounder of Reality Check Studios, was called on to design and produce the film's "Wake Angels" sequence, containing three and a half minutes of animation.

*Titan AE* begins as Earth is destroyed by aliens. The lead character, Cale, embarks to find a legendary spacecraft, the Titan, which holds the secret to humanity's salvation. The "Wake Angels" sequence is where Cale gets his first chance to fly a spaceship. The Wake Angels are dolphin-like space creatures who glide playfully through the nebula alongside the spaceship. The studio worked to define the look of the scenes by developing previsualization animatics based on the storyboards from Fox designers. Once the animatics were created, RCS artists spent about a month on research and development, determining how to produce the nebula environment—3D cloud-like, organic formations are difficult to do in CG. Animation for the nebula environment was done using Play Electric Image, and the Wake Angels were animated using Maya. The compositing was done with Adobe After Effects. Reality Check completed the sequence in about four months.



**Blur Studio used 3D Studio MAX to produce the demo video for Microsoft's X-Box game console.**

## Blurring the X-Box

Microsoft's X-Box video game console won't be available until next year, but they needed a demo video to show off its capabilities. In just four weeks, Blur Studio (www.blur.com) of Venice, CA went from concept to delivery on a 3D animation featuring a young woman and a giant chrome-plated suit. Blur had to work within strict limits to ensure the demo would be an accurate representation of the X-Box's eventual capabilities—such as only using single-source lighting and not using blur, film grain, and other effects. Using 3D Studio MAX, Blur still managed to produce nice effects for the dozens of articulated parts on the metal suit and the muscular grace of the woman. They did textures with Adobe Photoshop, composited with Digital Fusion, and did animatics with Adobe Premiere. The video debuted at the Game Developers Conference in San Jose.

## At the Movies with C-3D

C-3D Digital Inc. (www.3d.com) has developed a single DVD that delivers both 2D and 3D programming. The zDVD lets consumers view a program in either stereoscopic 3D or in 2D. The zDVD, which meets all DVD standards and is fully compatible with existing DVD players, also provides viewers with new options such as stereoscopic 3D menu functions, chapter points, and special features. Combined with C-3D Digital zVISION, a 2D-to-3D conversion process, zDVD lets C-3D Digital package and deliver recorded media of any type, from any format, as a stereoscopic 3D DVD. The company also operates C-3D Television Network, which they call the world's first and only broadcast network to offer stereoscopic 3D programming 24 hours a day, seven days a week .

## SIGGRAPH in the Big Easy

The annual SIGGRAPH conference (www.siggraph.org) is always a showcase of CG art and technology, and at this year's in New Orleans in sweltering late July, 3D vendors will be demoing new products and giving sneaks of upcoming ones. Look for big announcements from 3Dlabs (www.3dlabs.com) among others. Alias|Wavefront is scheduled to release Maya 3.0 for IRIX and NT.

The Web3D Consortium (www.web3d.org) will be having another Web3D RoundUP at SIGGRAPH, looking at the technical and artistic best in 3D on the Web. Check web3droundup.org for details.

Also at SIGGRAPH, Pixologic (www.pixologic.com) will be releasing the long-awaited 1.0 version of ZBrush for Windows, a great painting app that lets you spec 3D depth along with color and materials from a brush tip. ZBrush also has 3D primitives, lights, and modeling tools for sculpting. It's a synthesis of 2D and 3D that's easy to use and exports to other 3D apps. The secret to ZBrush is pixels that save color, material, and depth information, so modification calculations happen automatically as you edit. ZBrush 1.0 for Mac will be officially released at Macworld Expo New York in mid-July.

## Plant a Flower in a 3D Garden

In a joint venture between the BBC and ParallelGraphics, BBC Online has launched The Garden at www.bbc.co.uk/thegarden. The new site allows would-be gardeners everywhere the chance to plant a flower for themselves and friends in an interactive virtual environment. Created by ParallelGraphics (www.parallelgraphics.com) using 3D tools and VRML, The Garden is populated with birds, animals, and insects, and it benefits from year-round sunshine—a welcome relief for U.K. horticulturists. The neverending 3D environment also means you never run out of space to plant and grow your flowers.

Site visitors can customize the flowers they plant by selecting from a range of options at the CyberGarden Gallery, or they can create their own flower. As in the real world, flower owners must feed and water their plants at least every two days to keep it alive. Virtual caterpillars increase interactivity by becoming butterflies when they're clicked.

# Perhaps the first time a remake is actually better than the original.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## 3D Expo Makes Virtual into Reality

For the second week of May, the virtual world of 3D graphics became physical reality at the Santa Clara Convention Center in the heart of Silicon Valley, CA. The fifth annual 3D Conference & Expo brought together artists and technologists from across the country and around the world to teach, learn, and inspire each other.

Conference classes and panels covered much territory, from hands-on tutorials with 3D apps to abstract discussions of art vs. technology. One of the more popular classes, even with its Sunday-morning time slot, was The Business of 3D. A full classroom listened raptly to the ins and outs of running your own business from true veterans. It's not all pixels and palettes in our industry—even if you're the best artist around, you need to have a sound business plan or you're out of business.

Tuesday morning, VFX pioneer and visionary **John Dykstra** gave the keynote address, focusing on how you use CG technology to communicate your vision. Today, technology isn't about putting special effects in films, Dykstra says, it's about using digital tools to express ideas that feel real but don't exist in the real world. He warned the crowd about substituting "process worship" for artistic products. Effects don't communicate anything by themselves. Dykstra presented test shots from *Stuart Little* (see *3D*, February 2000), showing the work involved with creating 500,000 digital hairs on Stuart's digital head in every shot. Hot-rodded **Alias|Wavefront** Maya Fur technology did the trick, but Stuart's success wasn't based on pixels or algorithms—he was a good character, one who had personality, a look, and presence despite his virtuality.

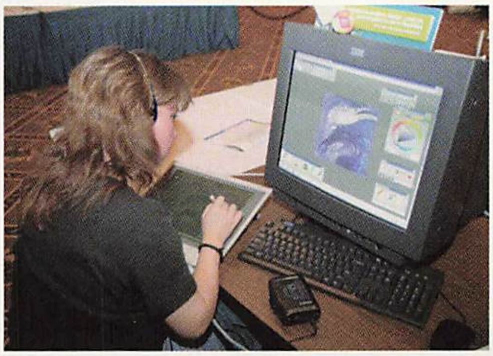
The Expo floor was filled with the latest in 3D modeling, animation, visualization, and web products. New software included **NewTek** LightWave 6.0 for Mac, **Maxon** Cinema 4D XL 6.0, and **Cycore** Cult3D 5.0. **Caligari** released iSpace 1.0 for creating 3D-rich web sites. **Pixels3D** is finishing its new RenderMan-compliant renderer, Tempest, to be released this year.

The Alias|Wavefront booth was doing nonstop Maya test drives. **Digital Immersion** drew crowds with their new combo of Merlin 3D software and Nav3D hardware, a rebranded Cyberpuck controller with six degrees of freedom. It's an intuitive match to the easy-to-navigate, fast-to-build 3D modeling and animation of Merlin 3D, which is popular with architects and game developers who can make walk-throughs or prototypes in minutes or even seconds. The company is currently working on agreements with prominent CAD vendors; the gaming market is its next target.

**3Dlabs** was demonstrating a new bundle of its own, an Oxygen VX-1 graphics card with StereoGraphics CrystalEyes wired stereo display glasses, to be available this summer. **Advanced Rendering Technology** made a big presence in a small booth with the beautiful image quality from the new RD 5000 RenderDrive. **Intel** was demoing the forthcoming 64-bit Itanium processor and announced strong industry support, including **Discreet** and Alias|Wavefront among the many who will be tweaking their apps to support the new floating-point processing.

**Our Big Kahunas for 2000, O.D. Wolfson and Tim Coleman, accept their coveted Kahuna head. Behind them is Van Phan, last year's Big Kahuna, who was on hand to pass the torch.**

Web 3D was one of the hottest topics at the Expo. Vendors such as **Metastream**, **Lattice 3D**, **Reality Wave**, **Hypercosm**, and **Superscape** have solutions geared at e-commerce for creating and streaming 3D. **Dimension-3D Systems** showed off its fast and well-priced 3D laser scanners. **Worlds.com** represented the end-user side of web 3D, with its 3D avatar chat system that's gaining popularity.



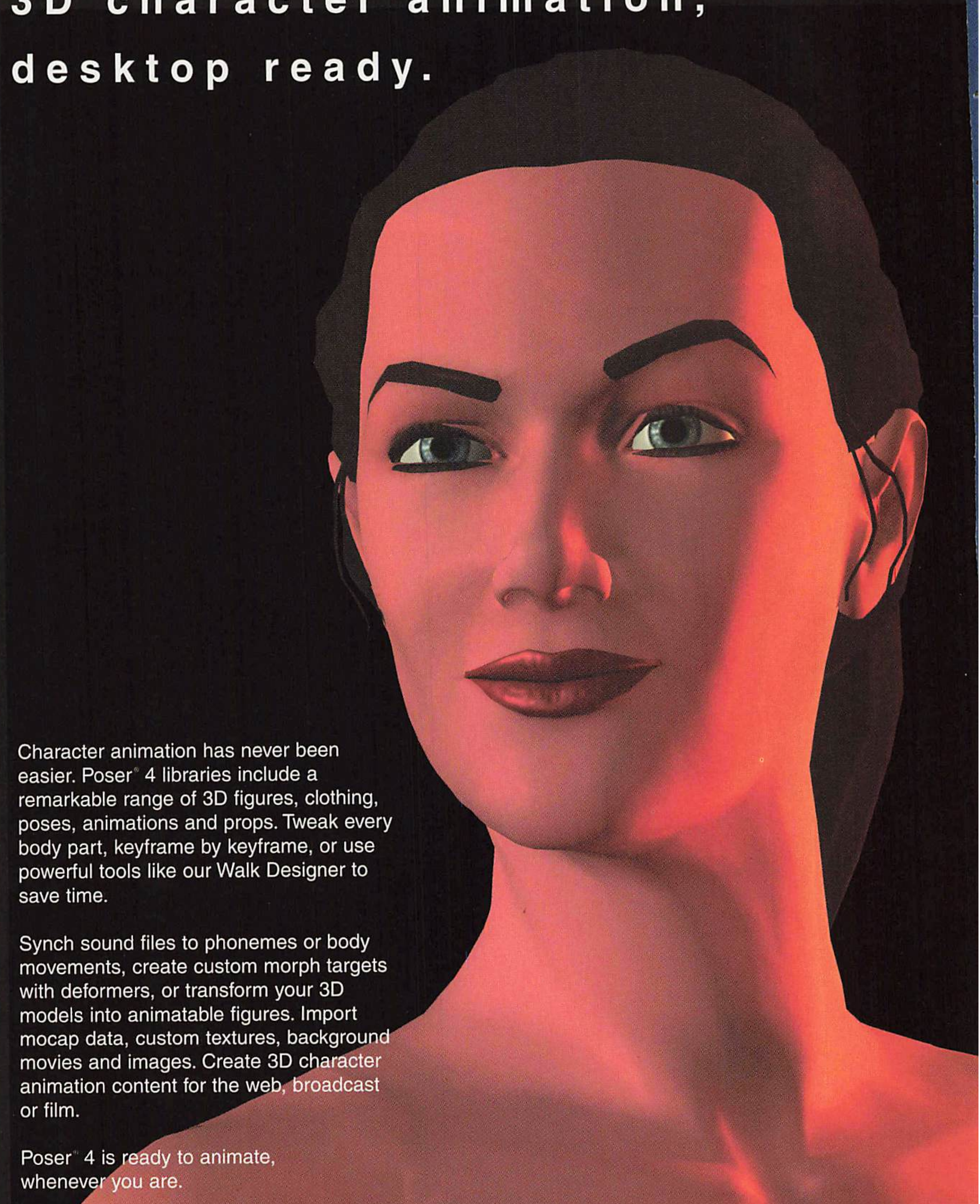
PHOTOS BY LES KAMENS

On the show floor and in the conference center's hallways, you could hear attendees and speakers alike talking about their new Internet companies. ("Hey, what are you up to these days?" "Oh, you know, doing the web 3D startup thing...") Web 3D is still in its childhood, but it's growing up faster than most people realize; not all the technology is commercially available yet and it's only getting better.

The large-format color printer kept running nonstop in the hands-on **Z-Zone** lab, rolling out huge, beautiful 3D artwork created by attendees, from painterly to fantasy to photorealistic and everything in between. Artists were discussing their projects, critiquing each other's work, printing their designs on T-shirts, and taking part in informal Z-Zone tutorials by Expo vendors.

It was fun, educational, and inspirational at the 3D Conference & Expo, even if people kept calling it the "3D Design Conference." We don't mind—people still call us *3D Design* magazine, too, a year after we shortened our name.

**Matthew Hoover was news editor and managing editor for *3D*. He's now riding his bicycle across the country in real time (literally—this ain't no VRML world), visiting friends and relatives.**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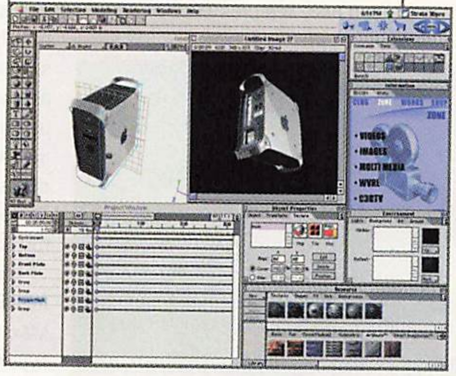
www.curiouslabs.com

## SGI NT & Linux Workstations

➤ In May, **SGI** formally introduced its next generation of Intel processor-based workstations, successors to the 320 and 540 Visual Workstations. The Silicon Graphics 230, 330, and 550 will be available with Windows NT or Red Hat Linux 6.1—SGI's first Linux workstation—and feature the new SGI VPro graphics with full OpenGL 1.2 support. (An even more robust version of VPro graphics for IRIX machines will be announced later this quarter.) Gone are the proprietary SGI graphics hard-wired to the motherboard. These machines are made from much more standard parts—nVidia supplies the graphics chips, for example, with specially tweaked drivers. Other specs include: Pentium III or PIII Xeon single or dual processors, 133MHz front-side bus, up to 2GB RAM and 90GB internal hard-disk space, and plenty of PCI and USB slots. The entry-level 230 (from $2,725) is available now; the 330 and 550 are scheduled to ship later this quarter. **www.sgi.com**

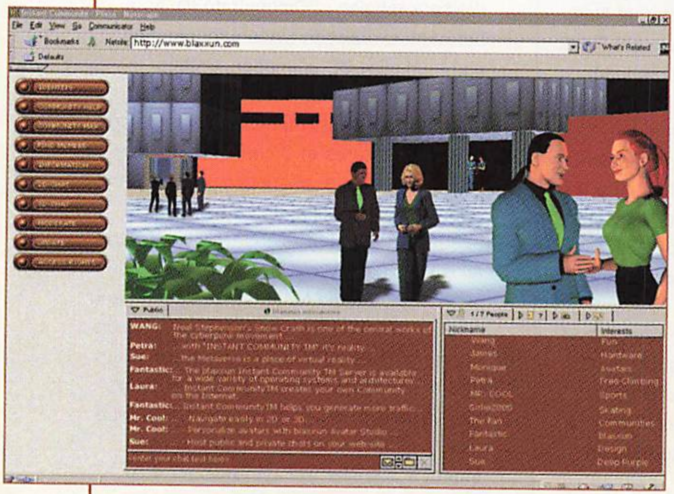

## Strata 3D for Free

➤ **C-3D Digital Inc.**, which acquired Strata Inc. last year, has released Strata 3D 3.0 as a free download through its subsidiary 3D.com. The update to Strata StudioPro 2.5.3 is a complete, fully functional version for Windows and Mac. (A boxed CD-ROM and manual is available for $39.) The company sees giving away software as key to establishing themselves as a leader in 3D content creation, especially for the Web, following the lead of Macromedia and Real. (C-3D Digital is also in the 3D broadcast and Internet market, so spreading 3D tools far and wide is key to its business.) You can purchase extensions for Strata 3D 3.0 from 3D.com and retailers, which include shaders and modeling tools. Sometime this summer, the company will begin selling Strata 3D Pro 3.0 ($595, or $89 upgrade from Strata StudioPro 2.5) with all available modules, Cycore Cult3D technology, project window enhancements, and support for the AltiVec processor used in Apple's chips. **www.3D.com**



## Instantaneous 3D Web Communities

➤ You can quickly develop virtual 3D communities with Instant Community 1.0 from **blaxxun interactive**, software that's more automated than the company's robust Community Platform. Targeted at web site operators, ISPs, and marketing agencies, Instant Community lets you create avatars and 3D spaces where people can meet and interact in public and private chats. Its template-based design includes 3D authoring tools for worlds and avatars, easy administrative tools, on-the-fly modifications, and support for up to 50 simultaneous users out of the box (more users requires a license key, which you can install while the app is running). Users connected via modem can navigate in 2D thanks to a Java applet. The full 3D experience requires a client plug-in, which is a free download for Microsoft and Netscape browsers under Windows 95/98/NT. (UNIX/Linux and Mac users are currently limited to 2D unless running VirtualPC or similar emulation software.) Instant Community 1.0 integrates easily with existing web sites and supports embedded links to other sites within the 3D environment. **www.blaxxun.com**




## RenderPipe for Maya

➤ **Advanced Rendering Technology** (ART) has a new Maya plug-in, RenderPipe, which offers a seamless interface between Maya and RenderDrive, ART's platform-independent, network-based rendering system. RenderPipe provides Maya users with integrated control and access to RenderDrive's powerful rendering features, Pixar RenderMan shaders, and physically accurate materials libraries from within the Maya environment. The plug-in will premiere at ART's booth at SIGGRAPH 2000 and is scheduled to ship in Q3 2000. The new interface will support Maya on Windows NT, IRIX and Mac OS X, once Maya for the Mac is available. **www.art-render.com**

## FireGL Burning Brighter than Ever

**FireGL Professional Graphics**, a division of S3, has announced its next-generation graphics accelerators, the FireGL 2 and FireGL 3, which are scheduled to ship this fall. (The Diamond Multimedia brand is no longer used for the FireGL line, but you'll still see it on their consumer products such as the Rio MP3 player.) Based on IBM's GT 1000 geometry engine and RZ 1000 256-bit rasterizer, the cards provide 30+ GFLOPS of performance. The GT 1000 engine is located on a separate bus to enable seamless transfer of data and avoid bottlenecks, plus it supports 16 simultaneous lights. The RZ 1000 rasterizer has single-pass bump mapping and multitexture support. The FireGL 2 will have 64MB of memory; the FireGL 3 will have 128MB and the ability to support dual monitors from a single-slot card. Both cards support OpenGL as well as full geometry transform and lighting operations, plus they have video support including bilinear scaling, video overlays, and a YUV-RGB converter for video and textures. Both are also optimized for Intel's SSE and AMD's 3DNow! technology. Pricing is expected to be less than $1,200 for the FireGL 2 and less than $2,000 for the FireGL 3. They will be on display at SIGGRAPH 2000 in July. The FireGL 1 ($699) will still be available as the entry-level card. **www.firegl.com**

## Visualize It in 3D

In an analytical vein, **TGS** (maker of 3D modeler Amapi) has released Amira 2.1, software for interactive 3D visualization, data analysis, and scientific reconstruction on Windows, Linux, and UNIX platforms. No programming is required; you can set up a visualization framework with a few mouse clicks. Amira 2.1 analyzes complex 3D data sets, and its techniques include segmentation tools, new algorithms for surface reconstruction, and a volumetric mesh generator for use in finite element analysis. Visualization methods include direct volume rendering (voxels), isometric surfaces, ortho- and oblique clipping plane (slice) viewers, vector fields, illuminated flow lines, line integral convolutions, camera path animations, mesh decimation, and more. Amira's uses are geared toward fields such as medicine (visualizing CT stacks or MRIs), engineering (computational fluid dynamics or material fatigue, for example), geophysics, and chemistry. Amira 2.1 supports many import formats, including OBJ, STL, DXF, VRML, TIF, and many more. Contact TGS for pricing information. **www.tgs.com**

## More & More Web 3D

As part of a strategic alliance with Discreet, **Hypercosm Inc.** has released Hypercosm MaxLink, a plug-in that converts 3D Studio MAX scenes into very small interactive files to deploy over the Internet. With Hypercosm's technology, compressed MAX files can have features such as mouse-over annotations, hyperlinks, animation, and simulation. MaxLink can also translate MAX scenes into source code in the OMAR (object-oriented modeling, animation, and rendering) language, so advanced users can add sophisticated simulation and animation features to their files beyond typical cause-and-effect. That's because the Hypercosm format deploys as applets, ultrasmall OMAR programs that run identically under Windows, Mac, and Linux.

You need Hypercosm Studio 1.3 (free download for Windows and Linux) and 3D Studio MAX to use MaxLink, which is a free download from **www.hypercosm.com**. Hypercosm Studio is the company's web 3D authoring package. To view Hypercosm files, you need the 3D browser plug-in, the Hypercosm Player for Windows, Mac, and Linux; it's a free download.


**Screen shot of a Hypercosm applet, an online owner's manual.**

**Kaon Interactive** has launched HyperActive, a new web 3D technology aimed at e-commerce, online gaming, and model sharing. HyperActive apps are XML-based, download to Netscape or Microsoft web browsers, and display interactive 3D content. The apps are smaller than similar Java or VRML files and can offer 3D pan/zoom/spin, chat features, spatial audio, whiteboarding, and more. The free downloadable HyperActive SDK includes an exporter for Discreet 3D Studio MAX 2.5 and 3.0 (www.discreet.com), and it works with 3DS, MAX, IGES, WRL, and other formats.

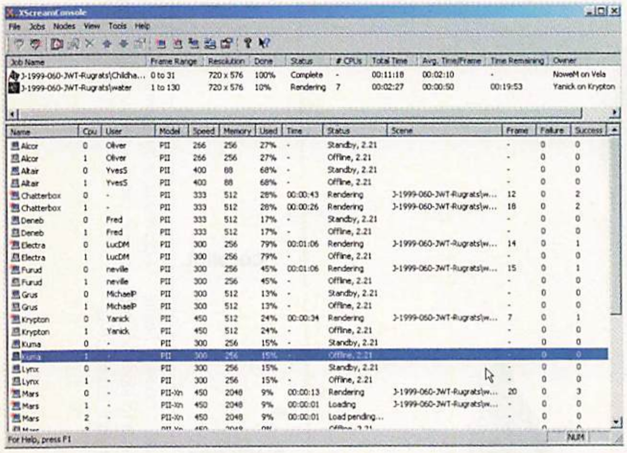
Kaon also offers photos-to-3D-model conversion software called HyperReality, geared toward displaying 3D products on the Web. (The company acquired 3D Construction Co. in April, who developed the 2D-to-3D software.) Models can be posted to a client's web site, Kaon's web server, or an application service provider's (ASP) facility. Those models can be accessed and manipulated within a web browser over a standard Internet connection. **www.kaon.com**

## Orchestrate Your Animation

**Improv Technologies Inc.** announced the beta release of Orchestrate3D. As a nonlinear production system for creating and managing 3D animation, Orchestrate3D works with existing 3D modeling software to create libraries of reusable content. Key features of Orchestrate3D Beta include multitarget animation, blending and layering, compositing, and a hierarchical sequencer. The first release will work with Alias|Wavefront Maya; future versions will support 3D Studio MAX, Softimage|XSI, and NewTek LightWave. Version 1.0 will be introduced at SIGGRAPH 2000 in July. For a limited time, Improv Technologies is offering Orchestrate3D Beta for free, including technical support by phone and online on Improv's web site. For Windows NT 4.0 SP4. **www.improv-tech.com**

# LightWave Render Power & More

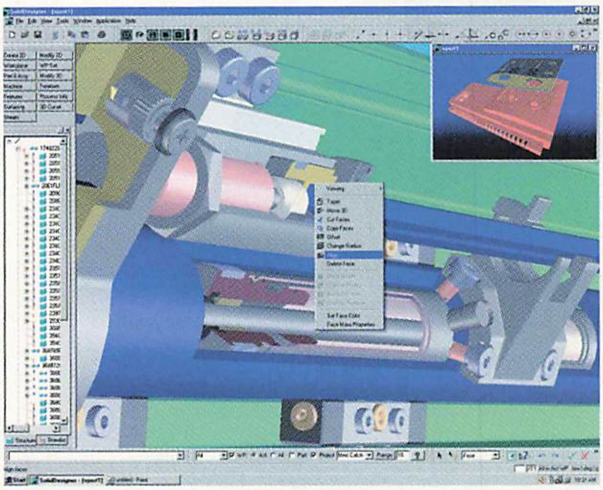
**Imagination In Motion**, based in Belgium, has released X-Scream, an advanced network-rendering solution for NewTek LightWave designed to give you full control over your render machines. X-Scream renders LightWave scenes on an unlimited number of machines and CPUs and automatically uses all idle processing power on your network. You can control your render from any machine on the network or even via the Internet. X-Scream products are available in three versions: X-Scream Personal ($250), limited to five machines on a network with a maximum of two CPUs per machine; X-Scream Professional ($1,500) for up to 15 machines on a network with a maximum of two CPUs per machine; X-Scream Enterprise ($5,000) supports an unlimited number of machines with an unlimited number of CPUs.



Imagination in Motion, a full-service 3D animation studio, also launched RealActor, a new technology for putting high-quality 3D animation on web sites. The player has technical features including multiresolution polygon structures, complex facial animation, speech synchronization, and advanced skinning solutions. RealActor comes as a freely downloadable 200KB ActiveX plug-in, and it's directed at branding, traffic attraction, and entertainment opportunities for web sites. Contact the company for pricing information. **www.realactor.com, www.iim.be**

## Solid & Collaborative 3D Models

**CoCreate Software**, a division of Hewlett-Packard, announced SolidDesigner 2000+ for 3D solid modeling and collaborative development. Four new modules within SolidDesigner provide greater integration with SAP R/3, better web-based collaboration, dynamic design alternatives, and dynamic assemblies for setting up positional relations among parts. Core functionality has also been improved, including efficient handling of complex blends and advanced surfacing. The collaborative enhancements let people all along the supply chain review, edit, annotate, and sign off on 3D and 2D designs, including photorealistic renders. For Windows NT/2000 and various flavors of UNIX; contact vendor for pricing. **www.cocreate.com**



## Feel the Tremors of Digital Compositing

**Nothing Real**, the folks who bring you the high-end compositor Shake 2.2, announced a new line of compositing software codenamed Tremor. Based on Shake's nonlinear processing engine, Tremor is an open, customizable compositor that's geared toward HDTV and film/video postproduction. It will feature real-time I/O, 3D compositing, tracking, keying, color correction, rotoscoping, and painting. Nothing Real's first installation of Tremor is a joint development with Post Impressions of London (**www.postimpressions.com**). The two companies are integrating Tremor's technology with Post Impression's SpiRINT multiresolution workstation to create SpiRINT FX, a sophisticated yet cost-effective software/hardware combo designed especially for HD.
**www.nothingreal.com**

## The Genie's Many MAX Controls

**Autonomous Effects (AFX)** has made available SceneGenie 1.2 ($995), the plug-in suite for matchmoving and combining live action and animation within 3D Studio MAX. The new CameraGenie utility for camera matchmoving requires no on-set measurements, generates camera track and point locations in seconds, and handles tripod-mounted cameras. The fast spot sensor interface has keyboard accelerators, mouse motions for heavy-duty use, and speed optimized spot tracker code. Download a demo version from AFX's web site. For Windows 95/98/NT/2000.
**www.afx.com**

## The Whoops Dept.

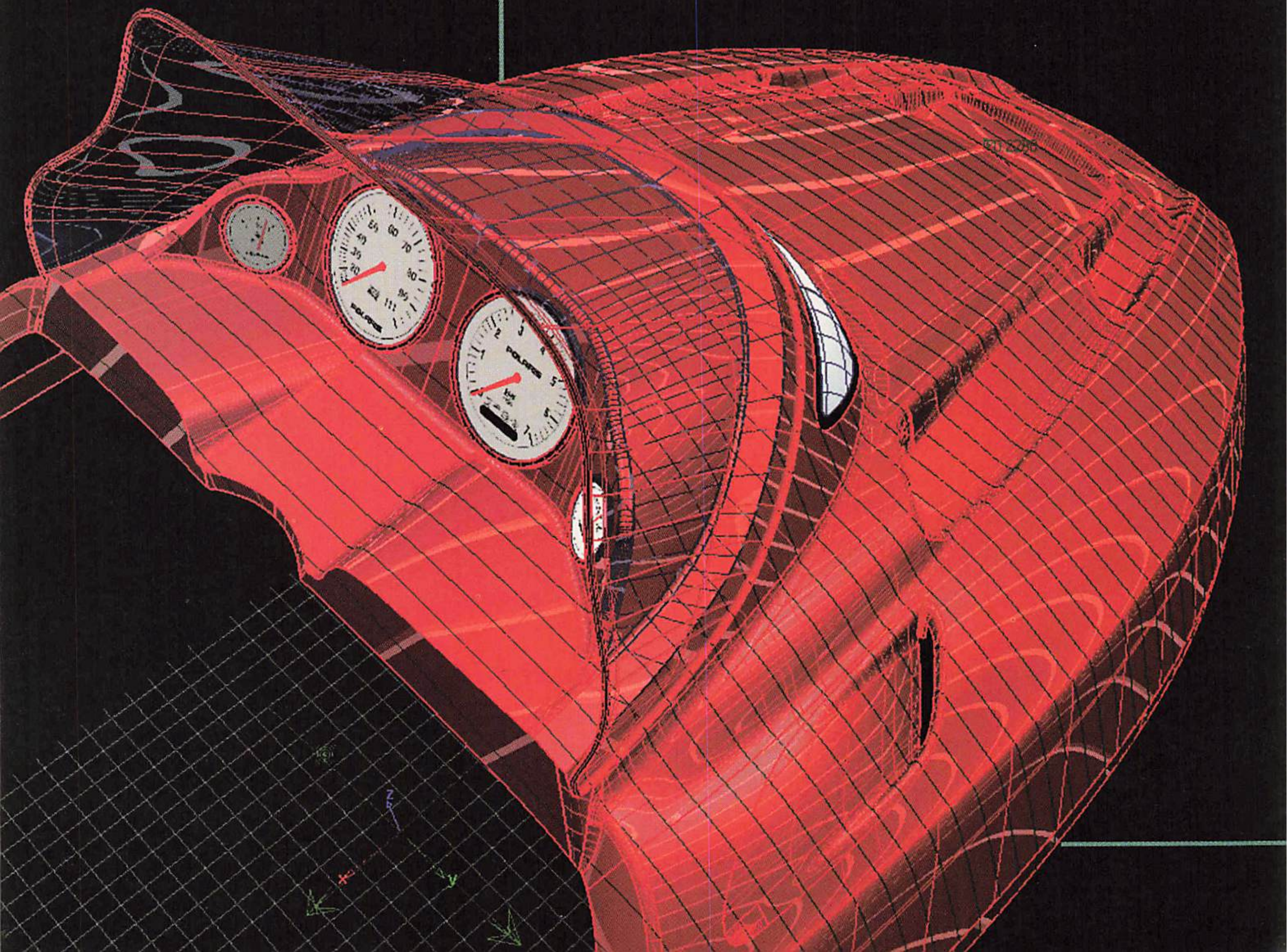
Regarding our April cover feature ("Ready, Set... Virtual!"): In our excitement to cover the amazing new 3DVSystems ZCam 3D camera system, we made an editing mistake and took a reference to Z camera depth that was written "ZCam" to mean the ZCam system from 3DV. SMA Realtime does not currently own a ZCam, and the infrared sensors discussed are part of the Orad virtual set technology, not the ZCam sensors. Although the ZCam can of course work with bluescreens, it's real power is that it doesn't need one. You can clip and replace imagery defined by any Z distance you like—extremely powerful. We apologize for the confusion and promise to mentally whip ourselves over this for a long time to come.

And our May issue list of Big Kahuna nominees didn't credit the beautiful "Shoulder Replacement Surgery" animation in the Scientific/Medical category to Chris Espinosa—but at least we got it right in June when he won! Apologies and congrats, Chris.

# Virtual Prototypes

by Joe Greco

**Product-development teams need to make items better, faster, and cheaper than before. Virtual prototyping can make that dream reality.**



# Take Shape

**Remember VR?** It's still here, and today's designers, engineers, and manufacturers use it to be first to market. To design, evaluate, and ship products faster, they need to take advantage of 3D visualization and CAD software, plus the Internet, to decrease the amount of time and physical prototypes in the product-development cycle. When you apply the visualization technology of VR to manufacturing, you get virtual prototyping. Whereas rapid prototypes are physical models made from 3D files, virtual prototypes are extremely accurate, robust digital representations of 3D designs that you can test, stress, and evaulate. We talked to two firms, and while each described numerous benefits of virtual prototyping, each often had different reasons for positive results.

**Brooks Stevens Design** If you believe the marketing hype, you'd think that everything today can be designed 100 percent electronically. While this goal is getting closer, "the main reason why we employ virtual prototyping is to shorten the product-development cycle," says Glenn Walters, IDSA. Walters is a senior designer/project manager at Brooks Stevens Design in Grafton, WI, a full-service product-development firm that designs for a variety of industries. Products range from recreational snowmobiles to high-tech medical devices. "A 100 percent reliance on virtual prototypes may work well for some firms because of the nature of the products that they develop, but not for us. We feel that the need for physical models still exists," says Walters. "Eventually something has to be built, for example, to test the heat given off by an engine or motor that goes inside of one the products we design."

Walters feels that, at least at his firm, today's technology doesn't necessarily result in fewer prototypes. "Sometimes we'll complete a project with only one or two physical prototypes, where we estimate it may have taken two or three without virtual prototyping technology, but most of the time we feel that it is a one-to-one correlation," he says.

"However, then we look at our production schedule and realize that we sliced 30 percent off of it," he adds. "This is due to many factors, but essentially what it comes down to is simple—the 3D data we create often replaces more traditional tooling methods. For instance, we've developed inline skates for Rollerblade where, by creating and utilizing virtual models, we've eliminated costly and time-consuming tooling aids such as tracing patterns."

**Why You Go Virtual** Walters is one of eight designers at Brooks Stevens Design who use Alias|Wavefront Studio for industrial-design surfaces, as well as animations for clients, who are usually the manufacturers themselves. Studio's intuitive, freeform modeling capabilities have allowed the company to get rid of clay and let designers handle sculpting from the onset, a major benefit. After the model begins to take form in Studio, Brooks Stevens designers create Apple QuickTime VR animations to show off the design. "QuickTime VR is great because you don't need a $30,000 workstation to run it on," Walters says. The firm makes its clients QTVR files with raytracing, reflections, and other sophisticated effects with with Apple QuickTime VR Authoring Studio and VR ObjectWorx from VR Toolbox Inc. "In a way, it's a type of virtual prototyping because it's mimicking reality while allowing the user to interact with the proposed design," he says. "You're showing design direction and giving product managers a higher degree of confidence in their decisions because what they see is what they get. It is sort of a WYSIWYG for 3D."

Designers are now creating and evaluating surfaces in a virtual environment that goes to tooling without a lot of reinterpretation. Evaluation software must be of the highest quality—you can't have a wrinkle or waver in a surface that shows up on the finished production part. Sometimes a model's flaws can be more visible in a virtual prototype display than a physical prototype, because the real model has usually been sanded and painted after production. In their evaluation process, designers at Brooks Stevens Design can catch potential problems while the part is being designed, before any physical prototype or tooling has begun, which saves time and money.

Virtual prototyping proves its worth in other areas as well. When looking at a shaded 3D computer model, you can't


**This virtual prototype of a Rolodex was created with Alias software by Brooks Stevens Design.**

know certain information—such as what's happening inside the model. By setting up section cuts, visualization software such as Eval Viewer (a companion tool to Alias|Wavefont Auto Studio and Studio) lets you slice models at any desired interval. "This also allows you to see transition areas and evaluate the surface curvature," Walters says. "It's like putting on glasses and everything suddenly gets clearer. It also gives you a better sense of scale, because you now know that all your section cuts are one inch apart, for example." Brooks Stevens also uses Eval Viewer to import and study point-cloud data from 3D digitizers for reverse-engineering purposes.

Creating virtual prototypes will lead you to more accurate physical prototypes, as well. In fact, Walters thinks that virtual prototyping technology is changing the role of physical prototypes. "They're needed less and less by the designer and more for engineering and marketing people." The designer has been studying the model in 3D on computer screens for several weeks or months and knows it very well, but someone like a manufacturing engineer can still benefit from a physical prototype to help visualize how something will be assembled on the shop floor. "True, there are programs that do this, and some of our clients use them from time to time," Walters says. "But most manufacturers want the physical prototype, and besides, a mass retailer is not going to buy 30,000 lawn tractors unless they can sit on a physical prototype and kick the tires."

As for marketing and other nontechnical people, they often best understand certain projects from physical prototypes. But for an image of a product, such as for marketing literature, a 3D render of your virtual prototype can do the trick. "Sometimes they need a photo of the product well before any real model exists, for instance, to sell a product to a retailer before costly development gets underway. There have been many times when the virtual prototype was rendered with such a high degree of photorealism that it looks just like a photo and can be used in their marketing brochure, eliminating both physical prototypes and expensive photography," Walters says.

Perhaps the final benefit of using virtual prototyping technology is economics. Walters sees its use at Brooks Stevens Design as one of the contributing factors to the firm's rapid growth over the past few years. "We have been able to compete against firms almost twice our size," he states.

The company has made use of both synchronous and asynchronous collaboration. Walters and his fellow designers have used Microsoft NetMeeting videoconferencing software on occasion to hold a virtual product review session (synchronous collaboration) with the mold maker and the manufacturer who assembles the entire product. They discuss tooling and assembly issues, as well as make visual decisions about the product shape, before any physical prototypes are made. "The bandwidth is lacking, but overall the NetMeetings go well," Walters notes. Other times, a predetermined animation is set up and simply emailed to the client, which is an example of asynchronous collaboration.

## Still a Place for the Physical

"Say what you will, but there are still advantages of physical prototypes," Walters says. He mentions that in addition to "kicking the tires," real prototypes are also used for engineering analysis such as heat testing. Again, Walters acknowledges that thermal-analysis software exists for the heat tests, "but I'm not sure how many people trust software for their final analysis," he says half-jokingly. "Besides, all that different software gets expensive, whereas with one prototype you can perform all your tests," However, he's not totally against analysis software to perform virtual testing. Brooks Stevens Design and their clients do perform finite element analysis (FEA) for structural evaluation, which determines, for example, wall thickness in a plastic part based on how it acts under stress. They have also employed mold-flow analysis to evaluate injection-molded parts to help determine the gate placement and cycle time. PTC Pro/Mechanica for FEA and Pro/Advisor for mold flow are the main applications in this area.

On the flip side of the coin, Walters discusses some projects where no physical prototypes were needed, because they would have been expensive or impractical. Often the scale of the product determines reliance on a virtual prototype. "We may not be able to build three or four physical variations of a 40-foot yacht, but we can produce many virtual models to climb aboard and walk around. In the past, we've used SGI 3D Inventor files exported from Pro/Engineer, the Alias format, as well as Scene Viewer to create a virtual 3D walkthrough of several boat design concepts. We've also had some success with Autodesk Lightscape in similar applications, but we've found that what might work well for low-polygon models of interior spaces may not always work for the smooth, glossy automotive shapes. For this we use software such as Alias|Wavefront StudioTools."

## Next Thing in Virtual Prototypes

Recently, Walters and others at the firm have begun to experiment with Macromedia Director. With this software, they can create virtual interfaces for electronics products that have displays, meaning a client can use a mouse—or even better, a touch screen—to press buttons on a virtual product and have

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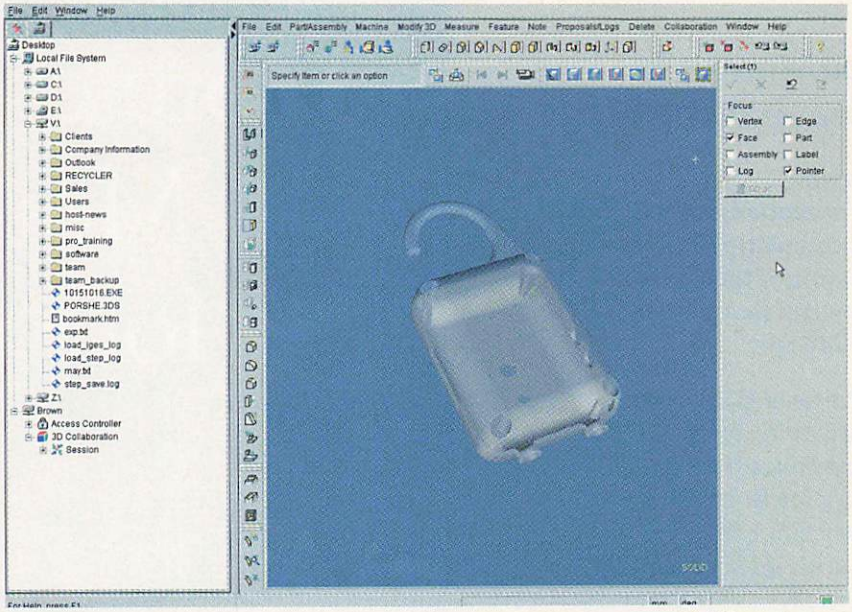
it respond as it would in real life. Walters is excited about this technology, and now that QuickTime VR supports Shockwave files, he's looking forward to trying this in QTVR movies.

Walters also sees a future where virtual prototypes are more portable. He senses that the continued advancements in computer graphics processing and faster network bandwidth will allow the transmission of even larger, more detailed 3D data and video streams to clients in an interactive environment.

**Visualize Better Products** A second firm I spoke with is Visualize, located in Roselle, IL. The company specializes in mechanical engineering but must develop products through their entire design/engineering cycle, because Visualize teams up with best-of-class partners who are industrial designers, electrical engineers, mold makers, sheet-metal designers, and so on. All of these partners use the same web-based collaborative software as Visualize.

"For instance, we tend to partner with tooling vendors who can build the tools right off of our 3D database," explains Visualize CEO Michael J. Pelland. "Of course, this means the solid model must be more robust—all the pertinent information to make a mold has to be there, including the draft angles, parting lines, witness lines, and so on." A robust model ensures proper communication among project team members, no matter where they're located, which leads to fewer physical prototypes, which in turn lowers production costs. CoCreate OneSpace is the app that allows users in remote locations to load in models from any number of MCAD systems they use to design virtual prototypes.

Unlike prevailing thought at Brooks Stevens Design, Pelland feels virtual prototypes don't shorten the design cycle. "A project that used to take three months still does, except now we wind up with a much better product because it can now be visualized and analyzed by numerous designers, engineers, manufacturers, marketing people, and so on." Pelland, who is still active as an engineer, adds, "While virtual prototypes do not decrease the length of entire product-development process for us, we get more 'turns' in the cycle and therefore end up with a better product that's much more



**CoCreate OneSpace allows remote users to load 3D models from any MCAD system.**

toolable, structurally sound, and aesthetically pleasing. In addition, there's no surprises downstream, because the product was a collaborative effort from the onset."

Products that used to encompass five or six physical prototypes "in the old days" now need only one, sometimes two. "We only need a second one if something was missed that we didn't see earlier. Most times, however, with the second prototype we don't have to build a complete one—we may only have to modify some of the parts and reassemble it."

Actually, Pelland doesn't like the phrase "in the old days," because the old days are still here. He points to many designers that are still building numerous prototype parts, sometimes from 2D prints. "Many of those who do solid modeling don't seem to understand that it's only one part of the product-development process," he says. "Many companies still operate under the old 'build it, test it, break it' cycle."

Virtual prototyping gives Visualize other benefits. "You're more confident that the design is going to work, which leads to less personal stress in the long run," Pelland says. As with Brooks Stevens Design, he credits new visualization technology with the growth of his firm, although the company is slow to hire because they're picky about the people they chose. Still, a firm that started in his garage just a few years ago has already moved twice, and the current 11-person company competes for jobs with organizations many times its size.

Pelland also differs from Walters in his vision of the future. He sees the entire process being on the computer with no prototypes, a sort of "100 percent computer product-development simulation." However, he feels that one aspect of the product-development cycle will still be manual for the most part—the foam models and cocktail napkin sketches. "The foam model still has a purpose for certain marketing-driven clients. They like to have a foam or clay model to show their buyers and say, 'Here is what the product is going to look like.' In fact, a good industrial-design person can knock off a foam model in a day—rapid prototyping and tooling can still take a few days or a few weeks," Pelland states.

**Whither the Cocktail Napkin?** Will even foam models and napkin sketches disappear in the future? Will every designer be equipped with a 3D pen that allows them to sculpt design concepts anywhere, anytime while still retaining a feel for the scale and that ever-important sense of touch? Eventually, sure, if you can wait long enough, but who's to say if it will be better. As of today, companies such as Brooks Stevens and Visualize prove that virtual prototyping technology is already being used to make products better, faster, and cheaper.

**Joe Greco is a writer, trainer, and consultant specializing in CAD and 3D. He has over 17 years experience in this field. He can be reached at joe3d@home.com**

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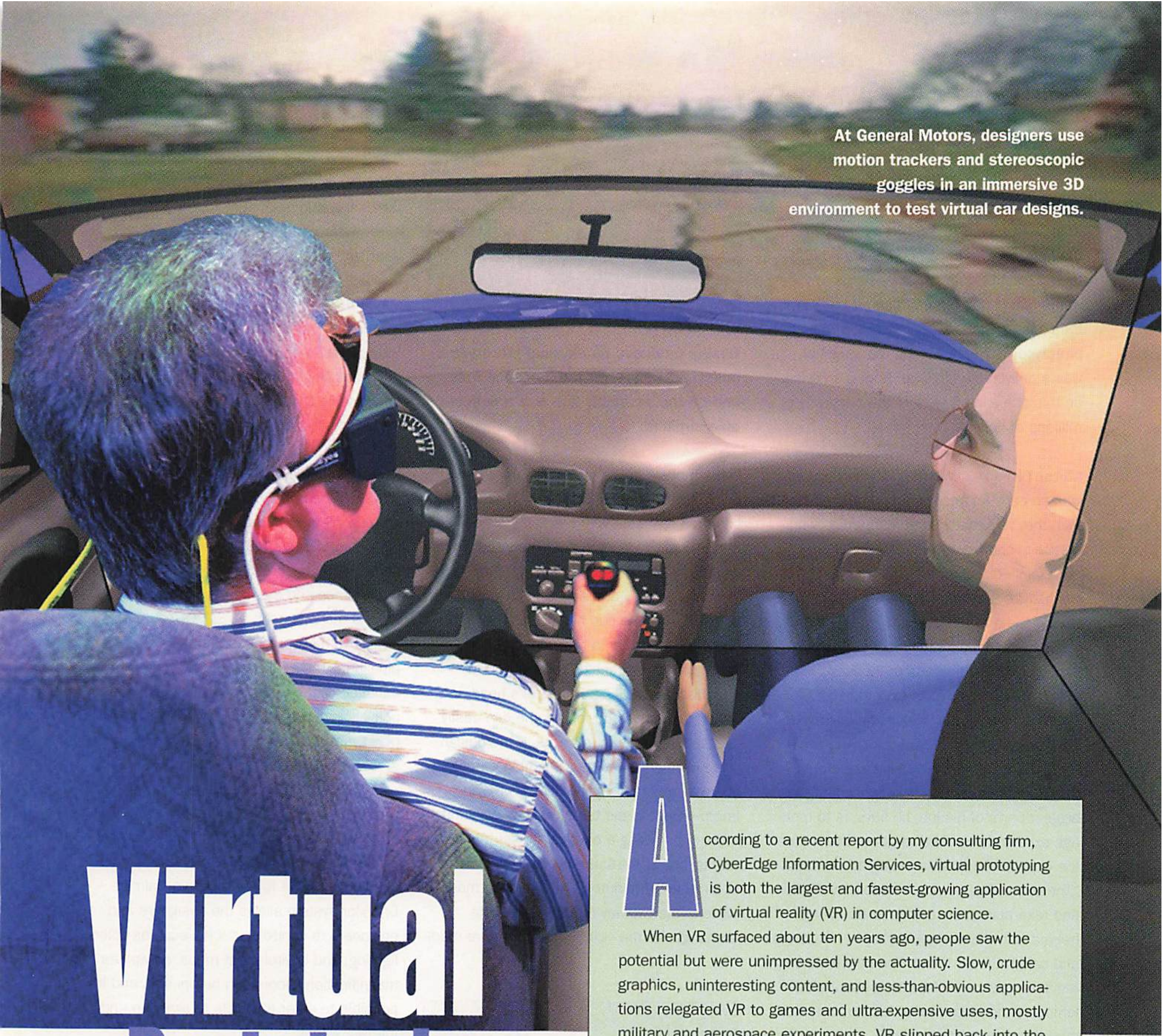

At General Motors, designers use motion trackers and stereoscopic goggles in an immersive 3D environment to test virtual car designs.

# Virtual Prototyping:

## VR GOES TO THE FACTORY

BY BEN DELANEY

DaimlerChrysler & General Motors design cars in virtual space before they build physical prototypes.

According to a recent report by my consulting firm, CyberEdge Information Services, virtual prototyping is both the largest and fastest-growing application of virtual reality (VR) in computer science.

When VR surfaced about ten years ago, people saw the potential but were unimpressed by the actuality. Slow, crude graphics, uninteresting content, and less-than-obvious applications relegated VR to games and ultra-expensive uses, mostly military and aerospace experiments. VR slipped back into the lab, where it waited for high-powered computers and fast graphics processors. Meanwhile, in universities and private laboratories around the world, experimentation continued. Over the past few years, manufacturing companies began to take another look at VR as a tool that seemed a logical adjunct to CAD. Since most engineering and design work was being done with computers, and the machines that make the parts were driven by computers, adding a visualization and testing step to the process was a logical extension.

Bob Ryan, president of Mechanical Dynamics Inc., whose ADAM software is one of the first commercial virtual prototyping applications, sees the value. "The virtual prototyping market is next phase of CAD/CAE/CAM implementation. We help eliminate hardware prototypes, which cost over $5 billion per year, including building, instrumenting and testing. Virtual prototyping will eliminate much of today's hardware prototyping—

the first model will be a production prototype, immediately prior to building."

Demonstrating this economy is Boeing. Its newest airliner, the $140 million 777, is the first plane to have been designed and tested electronically. No physical prototypes were built. It was the first aircraft certified by the Federal Aviation Administration without a prototype. The first 777 off the assembly line was a deliverable airplane. Boeing's savings on this one aircraft were in the hundreds of millions of dollars.

**Boeing produced no physical prototypes, only virtual ones, for the 777. The first one off the assembly line was a deliverable airplane.**

**Motor City Goes Virtual** DaimlerChrysler was an early adopter of virtual prototyping. In fact, they've already demonstrated a "workstation-to-showroom" vehicle, the LHS show car exhibited recently at major auto shows. DaimlerChrysler management is strongly behind the effort to evaluate designs virtually, since every physical model of a complete car costs hundreds of thousands of dollars and takes weeks to complete.

We spoke with G. Mukundan, advanced technologist at DaimlerChrysler, who evaluates and tests new technologies before they're put into routine service. One of the biggest parts of his job, he says, is to manage expectations. "You've got to make sure the expectation level is set right," he says. "The entire design, collaboration, evaluation, and reiterative process has to be re-engineered with the new technologies' functions and capabilities in mind. The new technology requires new ways of thinking about problems, and new ways to anticipate and measure the results," he explains.

Mukundan was instrumental in developing the virtual prototyping processes now being used by DaimlerChrysler designers from the earliest phases of product and component design.

In action, the design process is highly iterative and integrated with testing to create a faster, more efficient process. For example, a simple device like a cup holder can be really handy or a real irritation. To be sure that drivers find it a welcome feature, the designers and ergonomics people work together.

First, the interior designers produce quick sketches, which suggest the configuration and placement of the cup holder. These sketches are evaluated, and one or two are carried to the next stage—creating 3D models. The models are then integrated with larger models of the car's interior. At that point, ergonomic testing starts. The engineer sits on a real seat with a steering wheel in front of him. Wearing a head-mounted display (HMD), she can see the interior's layout and evaluate visibility and accessibility of various components. The cup holder positioning may be tested by having a real coffee cup in hand, with an Ascension motion tracker attached. By tracking the tester's head and hand position, it's obvious if she can easily see and reach the cup holder. If the design or positioning is wrong, it's simple to make changes and test again. "It's an amazing improvement in the time it takes," Mukundan says. "Reworking a physical model takes two weeks, but the virtual model can be changed in a matter of minutes." Adding even more value is the two-way nature of the data exchange. As the virtual prototypes are modified, changes are sent back to the CATIA Solutions system, and the CAD files reflect the changes immediately.

> "Reworking a physical model takes two weeks, but the virtual model can be changed in a matter of minutes."

The design teams work on SGI workstations and view their work on a number of devices, including an n-vision HMD, a Fakespace BOOM, and an SGI Power Wall. The 3D models are created using CATIA and Alias Studio, based on many 2D sketches created with Alias Studio Paint. 3D visualizations are done by the DaimlerChrysler Rendering System rendering software, which was developed in house.

Which viewing device is used depends on the job to be done and the number of collaborators. All the systems use Ascension tracking systems, preferred for their relative invulnerability to magnetic and metallic interference and their cost-effectiveness. Behind the scenes is an SGI Onyx2 Infinite Reality with six processors and two graphics pipelines. The design group is not currently satisfied with these solutions, though, and is actively investigating autostereoscopic display systems, both desktop size and in large-screen versions.

For large models, the Power Wall is the display of choice, since it can provide a full-size model of a complete car, and because long-term use of the HMD or BOOM is not comfortable. The fully interactive DaimlerChrysler system allows the designers and engineers to control variables such as color, lighting, and environment maps, as well as magnification. Doors can be opened, and it's possible to enter a vehicle to examine and interact with it.

Mukundan says that increased use of systems like this is on the way. "We try to use computer models as much as we can," he says. The savings in time and cost are so significant that management is strongly behind the technology.

**VR & GM** General Motors was an early pioneer in virtual prototyping. According to Randall C. Smith, staff research scientist with General Motors Research & Development and Planning, GM started exploring large, stereo, flat screens with head tracking in 1992. At that time, researchers weren't really sure what the technology's application would be, but Smith was so encouraged by the initial success of the large-scale visualization that work continued, and GM bought a CAVE immersive display from the University

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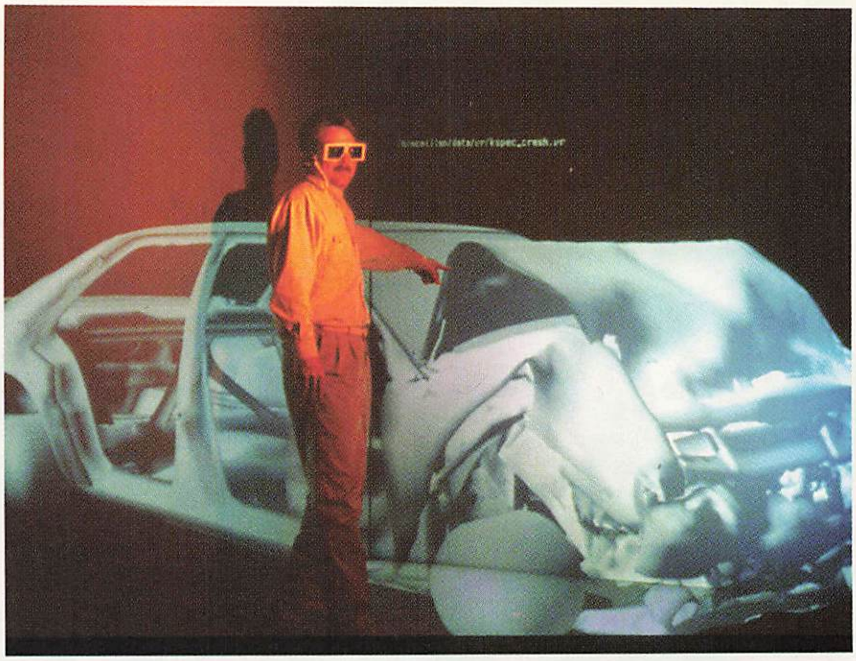
of Illinois in 1994.

Some of GM's first work involved looking at full-size auto interiors. Smith set up seats and steering wheels inside the CAVE, which enabled an engineer to take a seat inside a virtual car and determine how well the interior layout met ergonomic and functional requirements. From the beginning, GM's systems used Ascension motion trackers and StereoGraphics eyewear. The Ascension Flock of Birds tracking systems were chosen (and are still used) because they provide a good cost/performance ratio, and are relatively impervious to interference from metallic structures and electrical fields surrounding the work area. The StereoGraphics eyewear, used to provide stereoscopic viewing, is favored for comfort, ability to fit over glasses, and low cost.

In addition to off-the-shelf components, Smith's group developed viewing software called VisualEyes and a tracked pointing wand with control buttons. He has also overseen building of an 8-foot cube, more suitable for car interior visualization, plus another cube in Germany at GM's Opel subsidiary. All of GM's CAVEs are powered by SGI Onyx2 Infinite Reality systems. Alias|Wavefront software is preferred by stylists for 3D modeling, while engineers use Unigraphics CAD software for parts design.

While GM still uses its CAVEs for interior evaluation, several other applications have emerged from their years of experimentation. Surprisingly, a major contribution of virtual prototyping is not strictly technical but communicative. Says Smith, "We found that the biggest added value is as a communications tool. [The members of a design team] can all speak the same language: engineers, marketing people, and finance people find a common ground for their discussions and concerns." Virtual prototyping provides an intuitive visual language. In a visual-design review, an entire design team examines an ongoing project, full size, in a meeting-room environment and discusses it. They're able to manipulate lights, viewpoints, colors and other design features in real time; discuss the implications of the changes; and evaluate many more permutations than physical models would permit. Rather than have an abstract discussion, a heterogeneous team can move quickly to understanding and consensus. Furthermore, Smith says the system helps GM produce a better product because



**At GM, visualization provides a tool to analyze the massive amounts of data from a virtual car crash. Engineers can discover patterns by, for example, crawling around a wreck as it happens or cutting sections through the model.**

it enables more iterations and saves time in any particular design-review process.

He added, "I thought [the CAVE] would be a design tool or an engineering tool. I thought people would be designing interactively. The systems are not nearly good enough for that. What they are good enough for is providing a common, shared model that everybody understands. That's terribly important. It sounds simple, but when you think about it, it's huge. It works to get your idea across to the head of the company." The biggest bottom-line impact: faster time to market in a highly competitive business. Every CEO can understand that.

There is a more technical application of VR at GM. GM's engineers were early adopters of the virtualization of another key function—time-varying simulation, such as crashes. Temporal 3D simulation gives them a better understanding of the engineering process and how it relates to physical reality. In a real or simulated crash, a huge amount of data is collected. Visualization provides a tool to work with that data. With it, engineers can discover and see patterns that are only available through first-hand experience—not in piles of printouts. They can focus on key details, use their peripheral vision, see exceptions, rerun the simulation, change the lighting, see various angles, crawl around a wreck as it happens, and cut sections through the model. All of this helps them understand how their design will function under real-world stresses and enables them to reduce manufacturing costs.

Smith says of virtual prototyping, "It's been a very big success here at GM. The fact that it's being deployed speaks for itself. This stuff is quite expensive; it wouldn't be deployed if it wasn't worth it."

GM is actively looking for more areas suitable for this technology. They have found that once a visualization system is deployed for one purpose, other ideas materialize from the people who use it daily. Smith sees GM's visualization systems being applied to the manufacturing process, factory design, robot training, and model changeovers in the near term. A lot of commercial activity is starting up, and GM is working with outside vendors to help them create commercial applications to leverage the power of virtual prototyping in the workplace.

**Up Next: Virtual Assembly** Another application of virtual prototyping that's nearly ready for prime time is virtual assembly (VA) visualization. Intended to make it easier to manufacture complex products, VA uses simulation to test how parts fit together and provides new insights on the manufacturing process. By making it possible for engineers to test the fit of parts and the process of

assembling them into more complex devices, VA can save time and money, as well as making machines easier to build, maintain, and repair.

One of the leaders in the VA field is Dr. Sankar Jayaram, of Washington State University's School of Mechanical and Materials Engineering. He's spearheading the formation of the VADE (Virtual Assembly Design Environment) consortium, which is expected to include Caterpillar, DANA, Cummings, Komatsu, Paccar, Fakespace, Sandia, EAI, NIST, MUSE, AMA, DARPA, and SGI as founding members.

Jayaram has been working on VA for several years, but only in the past year has the price/performance ratio of computers reached the point where the technology is becoming practical. But several serious problems remain before VA can be put to use, and those problems are just now being solved. Issues tough to overcome included managing constraints and developing an interface that made the process obvious, easy, and consistently foolproof.

Jayaram stresses that the constraints issue was one of the thorniest. The challenge is to make virtual parts behave like their real counterparts. For example, when sliding a collar along a shaft in the real world, a hand or tool grasps the collar, fits it over the end of the shaft, and slides it along the long axis of the shaft. In the VA workplace, the virtual parts must have enough intelligence to know that the collar is only penetrable along a certain axis, that the shaft can only be approached from the end, that the shaft and the collar fit with a certain tolerance that restrains their relative motion, and so on. What's obvious and inevitable in the real world is a series of complex algorithms in the virtual world, and any error is immediately apparent to a human being. For VA to be both convincing to human observers and useful in terms of knowledge acquisition and transfer, the algorithmic aspects must be nearly perfect.

"Managing constraints was a real nightmare," Jayaram explains. Sliding a part along an axis by hand requires back-propagation of the resulting forces to the hand. A hand has six degrees of freedom, while the part doesn't. In real life, that means that the forces on the hand allow us to feel the optimal path. In the simulation, those forces must be "felt" by the computer, and the proper reactions must be computed to mimic the real world.

> **"We found that virtual prototyping's biggest added value is as a communications tool. Design team members can all speak the same language."**

"The other real challenge," he says, "was in gripping." In most hand representations in virtual environments, objects just stick to a hand representation as it passes by and activates a "grip" command. That was unacceptable for the VA system. How to grab with fingertips, instead of the whole hand, was a significant question. Using an Ascension Flock of Birds–tracked CyberGlove from Virtual Technologies, Jayaram's team built in the physics of motion, velocity of fingertips, and friction of parts. The effort has paid off with a realistic gripping simulation, one of the first developed anywhere.

The final challenge was two-way integration of CAD data. The models in the VA are nearly always developed in CAD systems, and the changes made to facilitate assembly must be fed back into the CAD system so they're reflected in the final parts. Complex models complicate the process; when many discrete parts and subassemblies are involved, they create recursive hierarchies of constraints. (A collar may rotate within an assembly that slides within a turning part.) VADE is designed in an open manner to use CAD software APIs to provide the required data exchange and to make it possible to plug future CAD systems into the VA system.

Advances in hardware technology, too, are making virtual prototyping a practical exercise. New computer systems, especially SGI's massive Onyx2 Infinite Reality systems, are cranking out visual simulations with speed and realism nearly unthinkable five years ago. Display systems such as MechDyne MDFlex, a reconfigurable CAVE-like display that unfolds to create a large-screen presentation system, and the Iowa State University system now under construction (which will provide a full cube with six surface projections) will make virtual prototyping in all of its aspects and applications more useful, less expensive, and more ubiquitous in the next decade.

The next generation of engineers will probably find it humorous that we actually would crash planes and cars to determine their characteristics in emergencies, or that we would build dozens of clay models to evaluate automobile designs. But the real benefactors of virtual prototyping will hardly even notice it. Consumers around the world will be getting better, safer, less-expensive products, thanks to the rapid progress and huge savings virtual prototyping brings to the manufacturing process.

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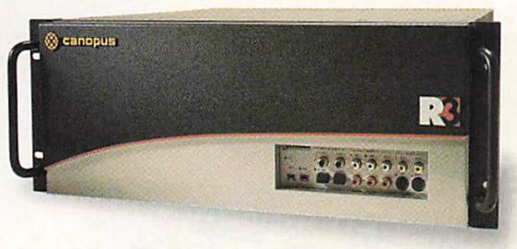


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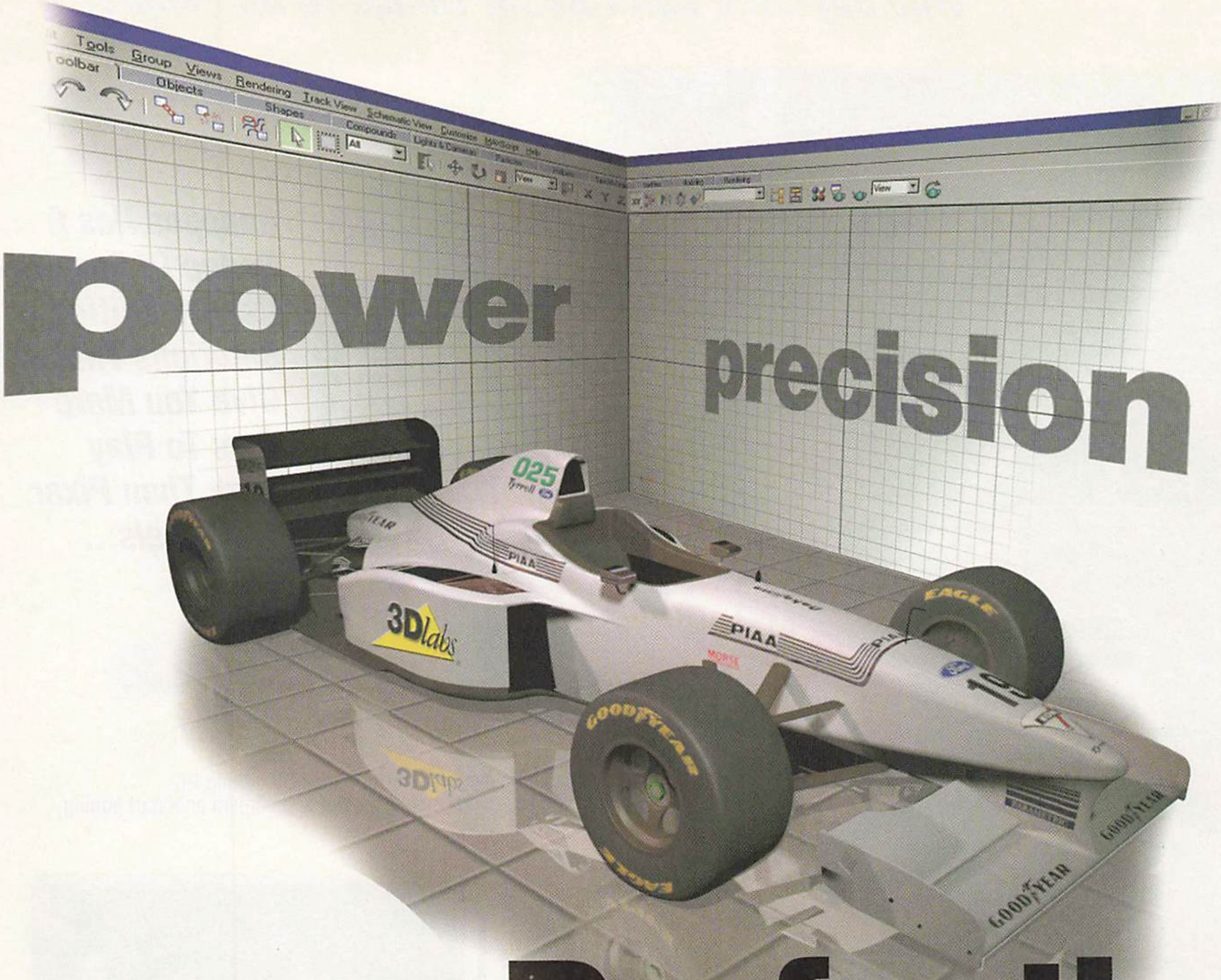



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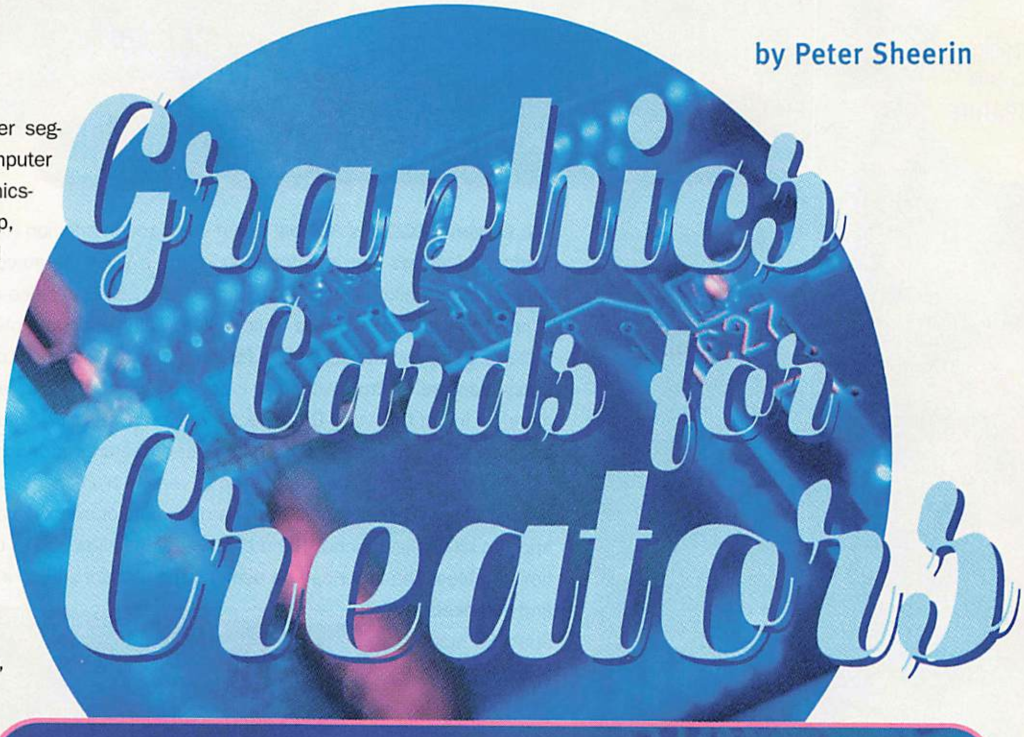
by Peter Sheerin

# Graphics Cards for Creators



**There are graphics cards for work and graphics cards for play(back), but when it comes to serious modeling the big iron is what helps you make that deadline. We test the best from 3Dlabs, Intense3D, Diamond Multimedia, & ELSA.**

More than any other segment of the computer industry, the graphics-card business has been shaken up, merged, changed strategy—and flaunted Moore's Law with impunity. Even as this is written, one of the earliest pioneers of PC graphics technology is closing its doors for the last time, and one of the newest is looking to fight the performance leaders of old for the king of the hill position. In the earliest days of the business, all graphics-card makers designed their own chips—out of sheer necessity. The last of these is gone now, and in the meantime the market evolved into a state where several graphics-chip companies existed that were selling their chips and reference designs to board manufacturers. After a spate of mergers and acquisitions, that process has come full-circle, with all but one chip-only company (nVidia) remaining. And with the imminent acquisition of Intense3D by 3Dlabs, the two vendors with the fastest boards will now be one as well.

With fewer vendors in the 3D graphics-card market, some might worry that there will be less competition than before. But I think this situation has a strong chance of increasing the competitive pace of development since these companies will be fighting for larger shares of the pie than before. There is also the potential for new entrants to shake things up, so none of these companies will have an easy ride.

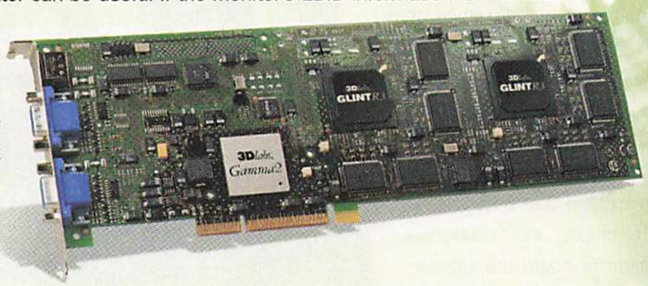
But by far the biggest change in 3D cards has been the dramatic performance gains and the improved visual quality. Features such as full-scene antialiasing and large numbers of textures can now be turned on without slowing your system to a crawl, and even very complex scenes can be manipulated in real time without having to resort to wireframe mode. Most surprising, though, is how close some of the more affordable cards come to the performance level of the most expensive ones. This puts very good performance within reach of every user, and forces those vendors playing at the bleeding edge to add value with features that go beyond just raw performance, and to redouble their efforts to convince ISVs to make use of the advanced features present in high-end cards.

We tested the cards' 3D performance using the 3D Studio MAX 3.1 benchmark provided by Discreet, the GLAZE 3.1 benchmark from Evans & Sutherland, the Lightscape viewer from Discreet (with the 2Rooms and Ponderosa models), and Viewperf 6.1 from Spec. The 3DS benchmark runs through x different scenes, animating the camera and/or objects, and includes wireframe, Gouraud-shaded, and textured models, to measure performance under a range of conditions. The two 3DS test results reported here stress large and complex geometry constructions (consisting of both meshes and lots of individual faces; the latter represents an area where I have had problems with several previous graphics cards) and texture acceleration. GLAZE is not even loosely based on any modeling or design application, but does a good job of testing pixel fill rate and in particular how well a card handles the combination of medium-sized models, textures, and transparency at once. The two Lightscape models represent medium and large architectural models, the former with only a few token textures and the latter being a million-polygon model with 14MB of textures—a real torture test. Viewperf is a collection of several benchmarks based on source code from actual visualization and MCAD products, including Discreet Lightscape, PTC Pro/Engineer, and a number of others. We include it here because its figures are referenced so often, and because it does show some useful results.

Despite being targeted for 3D designers, each of these vendors has a different view about what sorts of connectors are needed on the cards. The Diamond FireGL1 and the ELSA GLoria II feature only a VGA connector (the GLoria II supports an optional DVI-D connector for digital monitors, unfortunately not DVI-I, which supports analog and digital signals in one connector)—no dual-monitor support and no stereo sync. The other three cards from 3Dlabs and Intense3D all offer stereo sync and all but one offer dual-monitor support, but only the Wildcats feature DVI-I connectors, which is the only sensible way to add support for digital monitors to graphics cards. The Wildcat 4210 goes a step further by adding several display sync connections for synchronizing with other computer displays and with video streams.

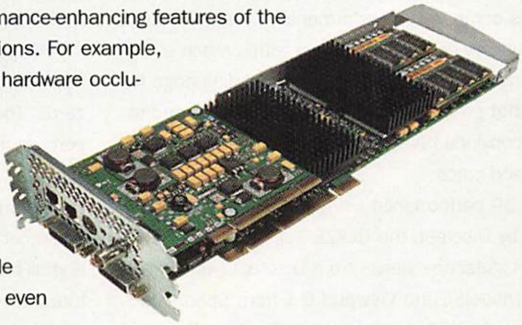
## 3Dlabs Oxygen GVX210

The Oxygen GVX210 is 3Dlabs' latest card, and in addition to offering great performance, it features dual-monitor support and a VESA stereo connector. And it achieves this while using just one slot. With 128MB of video memory, the card can support two displays at once while still providing adequate memory for the frame buffer, Z buffer, and texture store for each display. The driver control panel has straightforward controls without a lot of clutter, and the first level of configuration is merely a list of CAD- and DCC-specific driver optimization settings. The advanced settings allow you to customize a number of features for each configuration, including stereo support, 3D textures, sync to vertical blanking, and high-quality anti-aliased lines. Other settings, such as dual-monitor support and monitor settings, apply to all configurations. The monitor settings allow you to use DDC or preset timing tables. The latter can be useful if the monitor's EDID information is incorrect and you need to enable a mode (such as stereo) that the monitor supports but doesn't list properly.



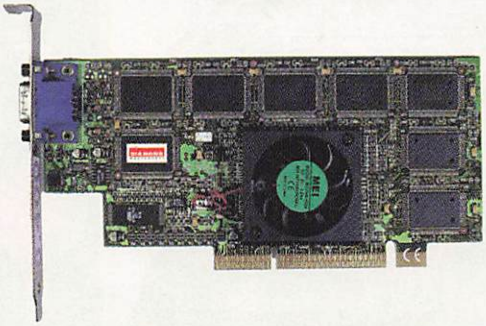
## Intense3D Wildcat 4110 & 4210

The Wildcat 4110 was last year's hottest, fastest graphics card. It requires two full slots (one AGP slot for the card plus an adjacent PCI slot to make room for the cooling fan, heat sink, and bracket). For the sacrifice of space in your system, you get one of the fastest graphics cards on the market, especially in accelerating real-time texture mapping. The 4210 adds on to that even better performance and double the memory. It is also the card with the most flexibility and advanced features. In addition to its dual-monitor support (via two DVI-I connectors for both digital and analog monitor support), it includes a stereo sync connector and video sync connections for genlock, frame lock, and rate lock. It also has the most memory of any card—256MB, with half of that devoted to texture memory. You may notice that while these cards turn in top-notch scores across the board, they aren't always the fastest—occasionally being nudged into second place by the much less-expensive ELSA GLoria II. This highlights the amazing price/performance value of the nVidia Quadro chip, but also shows that some of the performance-enhancing features of the Wildcat cards are not always used by today's applications. For example, Intense3D is aware of only four applications that use hardware occlusion culling—Softimage, HP SolidDesigner, MultiGen-Paradigm Vega, and SDRC. Applications that use features such as this (and that use lots of textures) will likely show a dramatic improvement in performance over the lower-end cards. If you absolutely have to have the best performance possible and use software optimized for it, there isn't anything even close to it on the market.



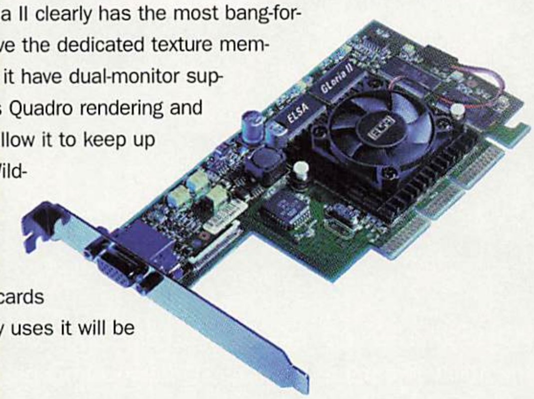
## Diamond FireGL1

Although the FireGL1 is the oldest card in this review, it still offers good performance and the lowest price-point of the group. Despite being the only one without a hardware geometry accelerator, it managed to take first place—by a nose—in the demanding 3DS Geometry 2 benchmark test. A PCI version is also available, and up to four cards can be installed in one system, providing multiple monitor support with one card dedicated to each monitor. It is the only card in this review that offers that capability, since none of the others are available in PCI versions. By the time you read this, Diamond will have announced the FireGL2 and FireGL3, which both offer hardware geometry engines, 64MB and 128MB of memory (respectively), plus dual-monitor support with the GL3, and much better overall performance.



## ELSA GLoria II

Last, but certainly not least, is the ELSA GLoria II. Currently the only card using nVidia's Quadro 256 chipset, the GLoria II clearly has the most bang-for-the-buck in this roundup. It doesn't have the dedicated texture memory that the two Wildcats do, nor does it have dual-monitor support or a stereo sync connector, but its Quadro rendering and geometry engine and AGP bandwidth allow it to keep up with—and sometimes surpass—the Wildcats in many of the tests we ran. Yes, if you throw tons of textures at it, or use software that can take advantage of the advanced features those other cards offer, it won't fare as well, but for many uses it will be just what the doctor ordered.



| | **GLAZE 15** (fps) | **2Rooms** (fps) | **Ponderosa** (fps) | **3DS Geom2** (fps) | **3DS Texture 1** (fps) | **3DS Texture 2** (fps) | **3DS Wire** (fps) | **Viewperf ProCDRS2** (geometric mean) |
|---|---|---|---|---|---|---|---|---|
| **GVX210** | 16.44 | 14.08 | 1.54 | 2.05 | 42.59 | 22.56 | 6.50 | 16.28 |
| **4110** | 17.55 | 19.96 | 2.09 | 2.07 | 55.95 | 24.93 | 6.71 | 34.74 |
| **4210** | 41.95 | 32.26 | 2.06 | 2.08 | 107.37 | 35.95 | 6.72 | 61.07 |
| **FireGL1** | 7.89 | 12.95 | 1.12 | 2.19 | 23.74 | 14.86 | 6.32 | 26.15 |
| **GLoria II** | 21.33 | 32.26 | 2.12 | 2.18 | 39.74 | 24.06 | 6.84 | 28.04 |

| | 3Dlabs Oxygen GVX210 | Intense3D Wildcat 4110 | Intense3D Wildcat 4210 | Diamond FireGL 1 | ELSA GLoria II |
|---|---|---|---|---|---|
| **Chipset** | GLINT Gamma geometry processor & dual GLINT Delta rendering engines | Wildcat rendering and geometry processor | Wildcat rendering and geometry processor | IBM 256-bit rendering engine | nVidia Quadro 256 rendering and geometry processor |
| **Memory** | 64MB SGRAM (with up to 256MB of virtual textures over AGP) | 64MB frame buffer, 64MB texture buffer | 128MB frame buffer, 128MB texture buffer | 32MB SGRAM | 64MB SGRAM |
| **Max. True Color Res. @ 75Hz** | 1920x1200 | 2048x1152 | 2048x1152 | 1920x1200 | 2048x1536 |
| **Special Features** | Dual-monitor support with 2 VGA ports, stereo sync | Single-monitor support with both VGA and DVI-I ports, stereo sync | Dual-monitor support via 2 DVI-I ports; stereo sync; genlock, rate lock, frame lock for multiple displays/ systems | Multiple card support (PCI version) | Optional DVI-D digital monitor daughterboard |
| **Bus Type/ Slots Used** | AGP 4x, 1 slot | AGP 2x, 1 AGP & 1PCI slot | AGP Pro 110/1 AGP & 2 PCI slots | AGP2x, 1 slot | AGP4x, 1 slot |
| **Price** | $1,299 | $2,000–$2,500 depending on system | ~$4,000 expected, depending on OEMs | $699 | $799 |

**get it on the web!**

**All of the benchmarks used in this article are available on the Web at www.3Dmagazine.net/2000/0628**

**What to Buy?** There are several cards that stand out (each for different reasons) in this review. The ELSA GLoria II is at the sweet spot on the price/performance curve and offers blazing performance. The 3Dlabs Oxygen GVX210 offers very good performance with dual-monitor and stereo support with just one slot. If price is no object, you need the highest performance possible, and require advanced features such as genlock for video synchronization, the Intense3D Wildcat 4210 is without peer, and should be at the top of your hardware wishlist.

**Peter Sheerin is technical editor for *CADENCE*, 3D's sister publication that covers the PC CAD industry. Contact him at psheerin@cmp.com.**

BY JESSE ANDREWARTHA

# Writing Shaders in RenderMan

**Don't be scared of a little programming. Fire up the logical side of your brain and create great textures.**

In 1988, Pixar developed and published the RenderMan Interface Specification, with the goal that it would contain enough descriptive power to accommodate advances in modeling, animation, and rendering for years to come. That objective has been accomplished. Today, most of the highest-end CG effects for motion picture films are completed using RenderMan. A significant part RenderMan's success can be attributed to its open specification for scene description and, particularly, its shading language. In this article, we'll explore the RenderMan shading language to create a procedural surface shader.

In 3D graphics programs, we're often presented with a limited set of tools to shade and texture our scenes. To create shaders, we often have to make do with presets, or rely on scanned textures, which have limitations. In contrast, with RenderMan we have a very rich shading paradigm to describe the appearance of our scenes.

The shading paradigm has four facets, each of which give you the power to fully describe a scene. The first is geometry; RenderMan has a comprehensive variety of geometric primitives and supports a user-extensible set of surface attributes. You can extend your primitive "library" with plug-ins such as Pixar MtoR (Maya to Renderman, which supports the use of Maya primitives). This lets you invent new parameters in a surface and attach them arbitrarily to objects' surfaces.

The second facet is the shader "white box" concept, which lets you influence the calculations going on within the renderer. In a typical "black box" scenario, you give the box the chosen inputs, and it returns results without you knowing where they came from. In contrast, with the "white box" system, you describe the box, and the system returns a set of unified inputs. This modularity makes it much easier to isolate concepts.

The C-like shading language is the third facet, which lets you write complex functions to fit into each "white box." It differs from typical C in that it has been specifically modified to describe the appearance of color and geometric calculations. The fourth is the highly extensible global environment provided by the renderer to the shaders. This environment gives the shader all necessary information about the points to be shaded.

**RenderMan's marble shader.**

The four facets combine to create the heart of the RenderMan shading environment: a complete and powerful tool for creating the highest-quality imagery, with the extensibility to let you create virtually any surface.

**How RenderMan Shaders Work** When entering the world of shading, it's important to understand how RenderMan compiles and applies a shader in your scene.

You create RenderMan shaders by constructing a text program file in the shading language. There are two types of files for writing and compiling RenderMan shaders: shading language source files (.sl), which are usually single shaders written in the RenderMan shading language, and shading language object files (.slo), the product after compilation of the source file.

Nearly every RIB file (RenderMan Interface Bytestream, a RenderMan input file) specifies a scene containing surfaces with shaders assigned to them. You can write the files directly in RIB format or compile them from C source code. MtoR, however, automatically constructs and executes RIB files, usually immediately prior to rendering.

Types of shaders include surface, displacement, imager, volume, and illumination. Surface shaders are assigned to surfaces with the Surface command, which requires the shader name and a list of optional shader parameters. When the renderer parses the RIB file and encounters the Surface command, it searches for a corresponding shading language object (.slo) file of the same name in a predefined directory. In this case, RenderMan would look for plastic.slo. The shader is then loaded into memory and executed as the scene renders. A warning message pops up if the renderer can't find a .slo file for any shaders specified in the scene.

**Preparation Before Programming** To write a shader in RenderMan, as with any programming task, you can take various approaches. Planning—before you write a single line of code—ensures a successful shader; some of these precautions do not even involve coding.

- Make sure you have good geometry: clean lines, averaged normals
- Know what look or effect you're trying to achieve
- Start with a shader closest in properties to what you're aiming for
- Work on various qualities of the shader's appearance one layer at a time.

Be clear about your objective. Get as many physical examples of comparable surfaces as possible. One of my production

**get it on the web!**

All the code's on the web! Go to www.3Dmagazine.net/2000/0628 to download this article with the full RenderMan marble shader code!

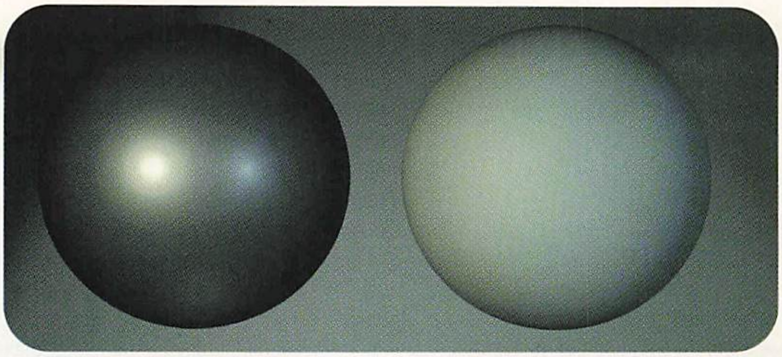


**FIGURE 1. The illumination model is the cumulative effect of the ambient, diffuse, and specular properties of a surface and how they reflect light.**

bosses once bought seven picot shirts to study their surfaces (although the attempted tax deduction was rejected by the IRS). Constructing a shader is an intensive task, fraught with challenges. Just as an animator may spend considerable amounts of time observing and studying motion to create a better character performance, so too must shader authors study real-world objects and surfaces to improve the character of their shaders.

Adopt the strategy of "divide and conquer" when it comes to writing shaders. Break down your surface into its distinct characteristics and concentrate on the most significant ones. If you haven't done enough observation at this crucial stage, your efforts throughout will be hampered. Straight out hacking a shader is discouraged; there's plenty of hacking further down the line. In the same way that CG creation has a particular workflow, shader creation requires strategy.

The layered approach to writing RenderMan shaders works well, as it helps standardize the shaders' structures and makes them modular. It's easier to reuse parts of existing shaders written this way in other shaders. Writing shaders in layers should be fairly easy—complex layers can be broken down further as required. Layers are always defined from back to front, compositing each layer as you go.

**Anatomy of a Shader** The RenderMan shading language is based loosely on C. Therefore, it's an advantage if you have experience with C and programming concepts such as variables, loops, and so on. A thorough knowledge of trigonometry and vector algebra is also handy, so if necessary dust off your high school mathematics textbooks and refamiliarize yourself with these areas.

Finally, a strong background in computer graphics helps you understand intermediate-level concepts related to illumination computations. If these concepts are foreign, don't despair. An abundance of resources is available to help kick-start your mathematics knowledge.

As in any programming language, variables in the shading language are extremely important. They let you give distinctiveness to surfaces and their illumination. With a whole shading language at your fingertips, you can manipulate variables to determine appearances. Not only can you compute new texture coordinates, you can compute entire patterns without accessing a single texture file. This is known as procedural texturing. Although RenderMan has full texture-mapping capability, proceduralism has many advantages, which include unlimited resolution, easy access to procedural patterns, and very small files to store.

**Surface Shader Variables** The global variables describe the color of a given point (pixel) on the surface, and a number of variables describe the color's property. Global variables may also describe bump mapping and displacements—these have been separated and are detailed later on. Table 1 shows global variables relating to the surface. You can declare local variables for your own use, analogous to local variables in C or other general-purpose programming languages.

**Illumination Models** Surface illumination is the cumulative effect of the surface's ambient, diffuse, and specular reflection properties (Figure 1). RenderMan provides methods to describe and manipulate each of these qualities to create a specific illumination model (the result you see when an object is lit, which defines its shininess or reflective properties). The most commonly used illumination model in RenderMan shaders is plastic, which combines all three reflection properties. Shader structure requires the illumination model to be added last. Earlier layers define only the color. It's also possible to blend illumination models to achieve surfaces with heterogeneous, or nonuniform, illumination.

Table 2 shows the variables used to calculate the shader's ambient, diffuse, and specular properties, which are used in the plastic illumination model.

**Displacements** Displacements are created when a shader varies the point *P*, resulting in a change in the surface's topology. This frees you from having to model details that are too fine, too frustrating, or require special shaping. RenderMan uses pixel-based displacement, as opposed to the tessellation-based

| Name | Type | Description |
|---|---|---|
| P | point | Position of the point you are shading. Changing this variable displaces the surface. |
| Cs, Os | color | The default surface and color, respectively. |
| u, v | float | 2D parametric coordinates of *P* (on the particular geometric you are shading). |
| s, t | float | 2D texturing coordinates of *P*. These values can default to *u*, *v*, but can be overridden |
| dPdu, dPdV | vector | The partial derivatives (tangents) of the surface at *P*. |
| time | | The time of the current shading sample. |
| du, dv | float | Estimate of the amount *u* and *v* change from sample to sample. |
| L, Cl | vector | Contain the information coming from the color of the lights, and may be accessed from inside illuminance loops only. |
| Ci, Oi | color | Final surface color and opacity of the surface at *P*. Setting these two variables is the primary goal of a surface shader. |

**TABLE 1. Global variables that affect a surface.**

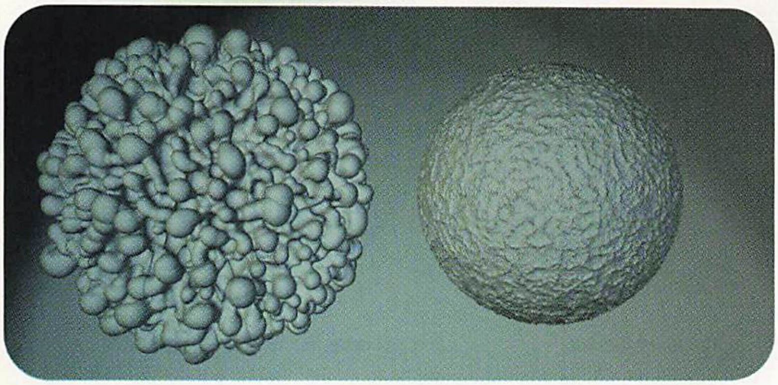


FIGURE 2. Displacements in RenderMan are pixel-based and yield higher-quality results than tessellation-based displacement. This image shows Ivan de Wolf's IDgloop.sl shader (left) and Larry Gritz's dented.sl (right).

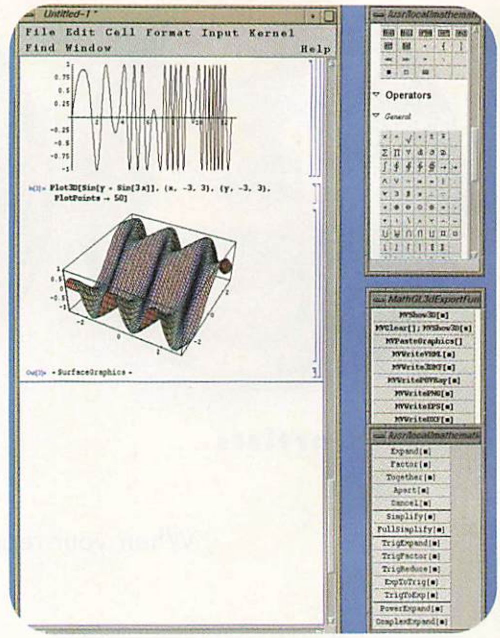



FIGURE 3. Mathematica can solve analytic integration for antialiasing, and can produce technical imagery.

displacement in many off-the-shelf renderers, which results in superlative results (see Figure 2). Table 3 shows variables used in creating displacements.

**Antialiasing & Shaders** Aliasing (the appearance of artifacts such as sharp jaggies, pixelation artifacts, twinkling, and creeping) is an unfortunate fact of life when writing shaders. Shaders are calculated at potentially regular intervals in parametric space, loosely coupled to raster units. Aliasing is caused when the frequency of the sample rate creating the shader is less than twice the frequency of the image function. This is known as the Nyquist Limit.

Texture maps in RenderMan are automatically antialiased, so they don't have the difficulties that face procedural textures. You could legitimately avoid using procedural textures, but this would deprive you of the freedoms a complete programmable shading language provides. Another option is brute force—literally programming the shader to sample at a higher rate, but this isn't a great solution, as it merely changes the problem by increasing the Nyquist Limit for that shader. Change the frequency and trouble may ensue!

The best approach is to prefilter the texture, returning the integral under the filter rather than point-sampling the texture function. Mathematica, from Wolfram Research (www.wolfram.com), is an incredible tool that can help you immensely with antialiasing. Typically used in high-end technical computing, Mathematica can create sophisticated technical 3D imagery and textures, and Jens Peer-Kuska has developed a plug-in, MathGL3d, that exports RenderMan files directly from Mathematica (http://phong.informatik.uni-leipzig.de/~kuska/mview3d.html). Due to its unlimited numerical precision, it's ideal for solving integrals for analytic integration (Figure 3). Analytic integration will yield exact antialiased results, but only a few functions have analytic solutions. Clamping the frequency—to keep it from rising above the Nyquist Limit—is another solution. Analytic integration and clamping are two of the solutions to the antialiasing problem in procedural shaders, but remember that any path chosen is a challenge.

**Shader Workflow** To make the task of writing a shader simpler, divide the workflow into four distinct sections: pattern generation, layers, illumination model, and compositing.

The first phase is the most fun, but also the most time-consuming. This is where the action happens, where the color is created. The second phase is layering. The most interesting patterns can't be described by a single function—you'll discover they're layers of patterns. Handle the layers separately, then merge them into the final pattern. The

| Name | Type | Description |
|---|---|---|
| PKa | float | Ambient reflection constant: percentage of light in a scene reflected by this surface |
| Kd | float | Diffuse reflection constant: percentage of diffuse light in the scene reflected by this surface |
| Ks | float | Specular reflection constant: percentage of specular light in the scene reflected by this surface |
| roughness | float | Specular roughness constant: concentration of the specular highlight |
| specular | color | Specular reflection color |
| **Auxilliary Variables** | | |
| Nf | point | Forward-facing normal |
| V | point | View vector |

TABLE 2. Illumination model variables, which calculate ambient, diffuse, and specular.

| Name | Type | Description |
|---|---|---|
| P | point | Position of the point you are shading. Changing this variable displaces the surface. |
| N | normal | Surface shading normal (orientation) at *P*. Changing *N* results in bump mapping. |
| Ng | normal | True surface normal at *P*. |

TABLE 3. Displacement variables.

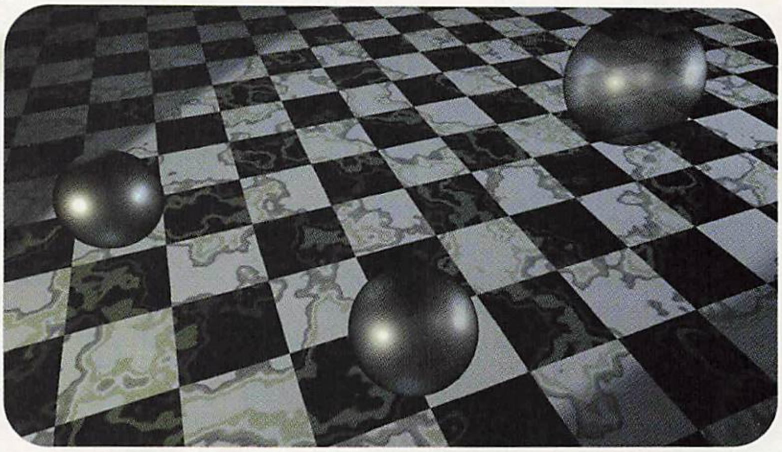


FIGURE 4. A render with our new RenderMan checkered marble shader. Using a procedural shader, there's no need to worry about resolution or tiling. You can download this article with all the necessary code at www.3Dmagazine.net.

third phase is the illumination model, how the surface reflects light. Compositing, the final section, merges the different layers to create the final complex shader. This method, keeping in line with the divide-and-conquer doctrine, lets you tackle complex shaders without going crazy.

**Bringing It All Together** To bring it all together, let's create a procedural surface. Consider a marbled checkerboard floor. The best thing to do would be to collect a range of reference images, or perhaps pieces of marble. Sit and ponder them for a while. Study their textures. Make a fool of yourself in front of your peers by walking around with pieces of rock in your hand.

After starting with the plastic.sl to confirm geometry, I went to my shader library and obtained code fragments for both checker and marble shaders. Providing credit is given where due, it is a completely legitimate practice to utilize shaders written by others. After all, there is no point in trying to reinvent the wheel. In order to recreate the effect of a checkered floor with a marbled texture, I had two options.

The first option involved treating the floor as though it consisted of two separate layers. The first layer consists of the white floor with a blue marbled pattern, and the second layer being the checkerboard, with a green marbled pattern in the black checkers, and transparent on the white checkers. This would reveal the whitefloor beneath. The second, simpler in construction, involved merely using a single layer. This would be a checkerboard floor, with blue marble in the white checkers and green marble in the black checkers. Choosing ease over layers, I went with the second option.

**Color** Marble color is defined even before the surface description is given. You define a range of specific colors to be used in the marble's banding, then apply them to a spline. In some senses, it's similar to creating a ramp texture. With the marble, however, you should have solid bands of color—a spline alone will create a blending of colors. To create this, you introduce a clamp, which clamps the frequency of the color, allowing only certain values to be displayed. This results in the correct banding in the marble. Once color is established, we can progress to the surface.

**Parameters** Following the surface declaration, which tells the shader compiler this is a surface shader, we declare the name of the shader, marble_CheckerBlack2, and list in parentheses the shader's parameters. Parameters control the shaders' appearance and may be manipulated directly in the RIB file. Variables, added after the parameters, are in effect hard coded. Once added, these values can only be altered by changing the source (.sl) file and recompiling.

**The Checkerboard** You first create the marble texture with the predefined color banding established at the top of the shader. You create it before the checkerboard pattern so it can later be called by the actual checkerboard procedure.

*S* and *t* are texture coordinates for the surface, in much the same way as *u* and *v* are surface coordinates for NURBS geometry. They generally vary from 0 to 1, and just like *u* and *v*, every point on the surface can be mapped with these coordinates. Since the shader is called once for each point on the surface, *s* and *t* can be regarded as constant each time the shader is executed. *smod* and *tmod* are variables, and they use the built-in mod function *mod(a,b) = a-n*b*, for an integer *n*, which allows a function to repeat over a surface. In our checkerboard, *mod(s*frequency, 1)* varies the *s* and *t* values *frequency* times over a surface. A set of nested *if* statements then selects a color based on the value returned by the *mod* function. In our case, values 0 to 0.5 are given one color, and values 0.5 to 1 are given another. This results in a checkerboard pattern.

**Shedding Some Light** After this final stage, it's time to add the illumination model. This brings together the ambient, diffuse and specular components of the shader. This can only be added at the completion of the shader code. If you add the illumination model earlier in the shader, any code after it will be rendered independent of the lighting. This, interestingly, results in an "incandescent" shader, and this technique may be used to produce such a shader.

**Debugging** Once the illumination model has been added, now begins the task of debugging. I have almost never had a shader work the first time I tried to compile it, and the marble_checker.sl file took one hour to fully debug. If you have been careful with your planning and procedure, this stage should be fairly straightforward. Only after debugging is complete, can we actually apply the shader to geometry and see it in action. Test the shader: render it close up, from a distance, under different resolutions and lighting situations. If necessary, return to the shader and tweak it to suit your taste. Once tested, apply it to your scenes (see Figure 4). They will never be the same again.

**Be an Author** Depending on your level of experience, the path to writing RenderMan

## SOURCES

**Pixar RenderMan ToolKit** · $5,000+
**Pixar Animation Studios**
(510) 236-4000 · www.pixar.com

**Mathematica 4.0** · $1,495
**Wolfram Research**
(217) 398-0700 · www.wolfram.com

**Blue Moon Rendering Tools** · www.bmrt.org


MultiGen
Creator

## shader programming resources in print & on the web

Information on programming shaders in RenderMan is plentiful; the key is knowing where to look.

***The RenderMan Companion*** (Addison-Wesley 1989) by Steve Upstill, although more than 10 years old, is required reading for any aspiring RenderMan freak. Unfortunately, it has a couple limitations. It's only intended as a first course so doesn't discuss many topics of technical interest and necessity, such as shader antialiasing and RIBs. It's also aging, and features added since publication are simply not there.

The best printed resource currently available is ***Advanced RenderMan: Creating CGI Motion Pictures*** (Morgan Kaufmann, 1999) by Larry Gritz and Anthony Apodaca. These two gurus of RenderMan have created an invaluable resource for your CG library. Gritz is the author of the Blue Moon Rendering Tools (BMRT) and is a software engineer in Pixar's graphics R&D group, which Apodaca directs. This book continues where *The RenderMan Companion* left off and goes far beyond. Everything is covered, from renderer architecture and the rendering pipeline, right through the shading language to PRMan's use in production. Veterans of the RenderMan User Groups and the Advanced RenderMan courses at SIGGRAPH will recognize some of the material, but it's extremely valuable to have all this information collated in one comprehensive volume.

Also available is ***Texturing and Modeling: A Procedural Approach*** (Morgan Kaufmann, 1998). Written by industry pioneers David Ebert, F. Kenton Musgrave, Darwyn Peachey, Ken Perlin, and Stephen Worley, this book is aimed at an audience with a thorough background in procedural computer graphics. Despite its advanced content, I've found it valuable in many situations and consider it an important resource in my library.

The Internet has a wealth of information. The RenderMan Repository (**www.renderman.org**) is one of the premier sites specializing in RenderMan. Its pages are devoted to downloadable shaders, hints, tips and tricks, utilities, and links to other RenderMan sites. The BMRT site (**www.bmrt.org**) is another valuable resource, loaded with information. Its RenderMan links page leads to almost every major site available that covers RenderMan-related subjects. I literally have reams of bound looseleaf from printing out resource after resource.

Finally, Julian Fong's RenderMan support at **Pixar** is a fantastic source of assistance, and Julian has been wonderful and inspiring as I forge my way through the RenderMan universe. If you have a current support contract with Pixar, help is just a phone call away.

shaders can be a natural extension of your skillset or a tough road with a steep learning curve. Regardless of skill level, writing shaders is a rewarding and fascinating task. I liken the production of my first shader to the first time I developed a black and white print in a darkroom. There's all this science—the optics of your lens, the chemistry of the film—analogous to the code you enter into the computer, all coming together to produce a work of art. When your first shader emerges from its code and appears in your scene, like the image springing forth on the photographic paper, you get a sense of wonder and accomplishment. There's nothing else like it.

**Jesse Andrewartha is a rendering technical director and resident daguerreotypist at ZeroG visual effects in San Francisco. You can email him at jesse@dimension7.com.**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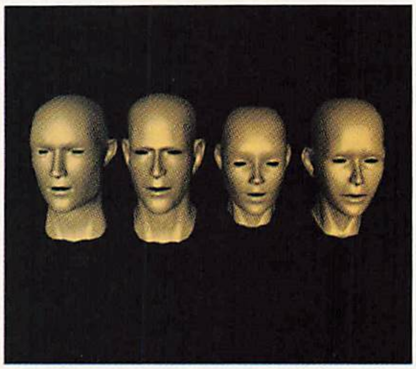

**FIGURE 1. Head Designer's four basic heads: two men and two women.**

## Sculpting Scalps

### Digimation Head Designer

**for 3D Studio MAX**

Clay, marble, or bits—no matter what the medium, sculpting the human head is a supreme challenge. It can take years to develop the chops necessary to produce highly realistic results. When it comes to virtual busts, Discreet 3D Studio MAX offers a variety of ways to get a head, including box modeling plus MeshSmooth, NURBS, and the skinned spline cages of Surface Tools. But even if you have the experience, building a new head isn't something you can accomplish overnight. A desperate client might believe you can, though, and you don't want to say no to a client.

Different as they are, heads have more in common than not. Just about all of them have eye sockets, ears, nose, a mouth, a chin, cheeks, a jaw, and a pate. So why not create a generic head with computer algorithms, and let the user customize it by adjusting the parameters? That's what developer Applied Ideas did, and the result is Head Designer, a nicely designed and implemented 3D Studio MAX plug-in published by Digimation.

Right off the bat you can tell this is quality software—you're not forced into a specific way of doing things. To create a head, you can drag in a viewport, or you can click, then move the mouse to adjust the head size, and then click to finish. What you get at that point is the eyeless Generic Man 1, one of Head Designer's basic head types. The other basic types are Generic Man 2 and Generic Woman 1 & 2 (they're lined up in Figure 1).

The four types are available from the first of Head Designer's six rollouts, Head Shape. Other settings in this rollout include Deformation Strength, which causes the head to puff up, along with the ability to "pull" and offset the deformation along various axes. Here you can also set scaling factors separately for each of the three axes, with skewing options for each. This effectively creates a tapering effect, so it's easy to create a pinhead (Figure 2). You can also compress the face, which effects proportional front-to-back scaling, and set the top flatness and forehead slope.

The next four rollouts offer a wealth of settings for different parts of the head. The Nose rollout lets you set the width, with an option that determines whether the nose is wider at the bottom or the top. If you're going for a Pinocchio look, you can lengthen the nose to ridiculous proportions. (In fact, extreme values for most of the parameters create unlikely, if not hilarious-looking, heads. For undisciplined users, the program offers the ability to restrict the value ranges to more-or-less realistic settings.) Back to the nose: Other settings let you create a hooked or pug nose, and pull the bridge in and out. No settings for nose hair, though. In fact, there's no hair anywhere on these heads; you'll have to provide your own virtual wigs or use an additional plug-in such as Shag: Hair.

**FIGURE 2. Bill Griffith (creator of Zippy the Pinhead), eat your heart out!**

The Chin/Jaw rollout gives you settings for chin length, just right for creating a Margaret Hamilton (the wicked witch from *The Wizard of Oz*, 1939) lookalike. You can also tilt the chin up and down and even curl it around a bit. For a manly man, you can increase the jaw width. You can also set whether the widening occurs toward the front or the back of the jaw.

Cheek bones have a major influence on how a face looks. Head Designer's Cheeks rollout lets you set how far the bones protrude, and their vertical position. You can also use the Curvature setting to create sunken or puffy cheeks. And in the latter case, you can set vertical position as well as falloff on two axes, which enables some fairly distinctive effects.

The final bunch of settings cover the eyes, ears, and mouth; the latter offers a Protrude setting only, for that thoughtful, pursed-lip look. The eyes have controls for separation, how far they're inset or bulge, the roundness (or squintiness), and brow bulge. And for the ears you can increase (but not decrease) height, depth, and lobe length. But the coolest ears setting is Rotation, which lets you flap them like Dumbo!

That brings us to the animation consideration. You can keyframe every parameter, which leads to some interesting animation possibilities. There are no settings for facial expressions such as smiles or frowns, though. Moreover, if you want to attach a head to a body, you must convert it to an editable mesh, which means you can kiss those parametric animations goodbye. Of course, MAX has good morphing capabilities, and creating morph targets with Head Designer is a no-brainer.

With all these settings and four different heads to start with, Head Designer lets you create a virtually infinite variety of heads. It even includes a utility that generates up to 100 heads with random features. Once you come up with a great settings combo, you can save and load it as a preset. The software comes with a small but interesting variety of presets including Mad Scientist, Muscle Head, and the old standby Geek (chicken not included). For those of us without the extra time and/or skills to create heads on short notice, or for anyone who just wants to have fun with that most important of organic objects, Head Designer is a wonderful toy and a useful tool.

## Set It on Fire

### Digimation Phoenix

**for 3D Studio MAX**

Ever since man discovered fire, he's been preoccupied with forcing it into his yoke. We tamed real-world fire, for the most part, quite some time ago, but in the world of CGI we've yet to come up with a convincing simulation that's accessible to the major-

ity of 3D users. Typically fire is faked with particle systems, applying transparency maps and age-influenced color maps to the particles while trying to get them to stay close enough together to look like flames instead of a mass of dots. You've probably seen particle-based fires in games and animations that conveyed what they were supposed to be, but weren't very realistic.

Stock footage, such as VCE's well-known Pyromania products, is another way to incorporate digital fire. Being photographs of actual fire and explosions, they're certainly realistic. But because such imagery is 2D, its use in 3D graphics is limited.

Aiming to resolve this dilemma is a new 3D Studio MAX plug-in called Phoenix, developed by Chaos Software (www.chaosgroup.com) and distributed by Digimation. Implemented as an atmospheric effect, Phoenix couldn't be easier to use, if you just want to go with the defaults. Add it to the scene, then specify the emitter object—that is, the object on which the flames will appear. You can use just about any type of object, including splines and NURBS curves; mesh, patch, and NURBS objects; and even particle systems. You can't use part of an object (i.e., a subobject selection) as an emitter, nor can you use multiple objects. However, you can create as many fires as you want, with one atmospheric effect per emitter object.

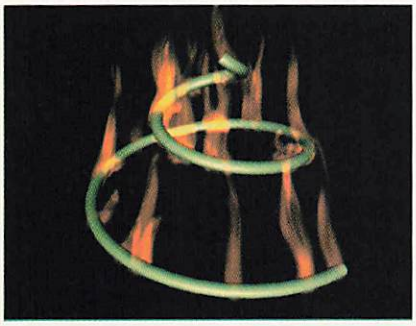

**FIGURE 3. A helical spline using Phoenix's default settings.**

Hmm, "emitter"... that sounds like a particle system. Actually, it is, but not just any particle system. Based on fractals and splines, Phoenix includes a slew of special controls dedicated for creating combustion-oriented effects. Without getting too detailed, flames are visible trajectories of particles as they travel along spline paths that can bend and change shape over time. The result is a convincing flame that animates very much like the real thing.

Once you've specified the emitter object, you can render flames immediately (Figure 3), but the results may not be quite what you're expecting. Typically, you'd first want to increase the number of flames, a simple numeric setting (Figure 4). You might want to change the flame angle, which you can also do with numeric settings, but it's easier by adding a custom vector object that you can rotate to vary orientation. You can also set the length, not by scaling the vector object, but with a numeric setting. You can see the results of all these settings without rendering courtesy of Phoenix's Build Shape Node function, which displays the flames as orange lines in the viewports and updates manually or automatically. That's quite helpful, because, being a volumetric effect, flames can take a while to render.

I mentioned that you can't burn subobject selections, but Phoenix provides two flexible solutions for applying flames to parts of an object. First, place as many atmospheric gizmos as you want, tell Phoenix to use them, and then flame on—only where the gizmos intersect the emitter. Of course, you can move and scale the gizmos and animate any such transformations for traveling, growing, and shrinking conflagrations. If gizmos don't do the trick—for example, when you need a particular, complex arrangement of flames over an object's surface—use the luminance values of any MAX map, including bitmaps, to specify where flames go.

Other important parameters include Spawn Rate and Kill Rate, which control the number of flame particles created and destroyed per frame. These can be set to fractional amounts for adding flames only every several frames. You can also specify a start frame for the process of adding and removing flames. And the single Flammability parameter controls how long each flame takes to fade in and then out again.

Phoenix's Appearance rollout lets you visually customize the look of the fire with a gradient tool that controls how colors change between the inside and outside (Figure 5). If you've ever used a software tool that lets you create a multilevel gradient, such as KPT, you'll be right at home with this one. You can move existing level boundaries, add and delete intermediate boundaries, and change any boundary's color. It also gives you parameters for overall brightness and density, alpha channel control, a separate preview window, and more.

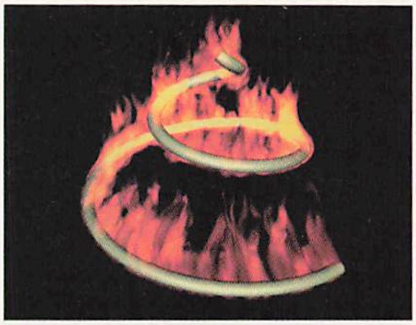

**FIGURE 4. The helix burning with more, shorter flames.**

Last but not least, Phoenix gives you more control than you'll probably need (but it's nice to have) over fractal parameters, including distortion fractals, used to control the shape and animation of the flames, and color fractals, which affect various aspects of how colors look and change within each flame.

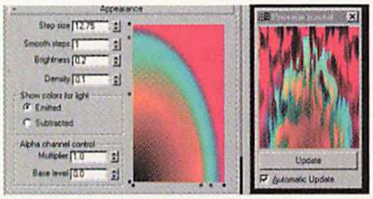

**FIGURE 5. Phoenix's Appearance rollout lets you set flame coloring.**

A couple final notes: Phoenix flames don't act as light sources, so if you want them to cast flickering illumination over nearby surfaces, you'll have to fake it. On the plus side, being color atmospherics, they don't require illumination. Also, the current documentation doesn't include any tutorials, so be sure to head over to Chaos' web site and grab their HTML tutorial, as well as a number of inspirational examples of what the software can do. Other than those minor caveats, I found no cause for complaint with Phoenix, and recommend it highly for fire fans everywhere.

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## sources

**Head Designer** · list price $195
**Phoenix** · list price $395
**Digimation**
(800) 854-4496 · www.digimation.com

BY FRANCIS X. McAFEE

# Shake, Composite, & Roll

## Nothing Real Shake 2.2

Always looking for a killer app, our research center, The Florida Center for Electronic Communication, found an excellent compositing application for high-definition production. Nothing Real Shake 2.2 complements our existing high-end 3D animation tools by providing film-quality, 32-bit processing, multiplatform capability, and extreme performance in a compositing program.

Designed from the ground up as a tool for compositors in the feature film industry, Shake 2.2 handles massive amounts of data, handles various resolutions simultaneously, and utilizes the wide spectrum of color detail required for film. Compositors can animate just about all values on most parameters and use a curve editor to adjust these effects. Shake 2.2 is both artist- and programmer-friendly, letting you work in the GUI, by command line, or programming in C. It's appropriate for high-definition or lower-resolution video, game development, film work, or multimedia content creation.

The first thing you'll likely notice is the impressive playback speed of the flipbooks of your composites. While no special graphics hardware is required, fast SCSI drives and hearty helpings of RAM make the difference in playback performance. It's even possible to speed up playback to far greater speeds than 30fps. Pressing the + or – keys on the number pad will adjust playback speed.

Just for kicks, I tested Shake 2.2 on my homemade overclocked Celeron with an old RIVA TNT video card and then, to add a more professional element to this review, on a dual-processor SGI Onyx2 with Reality Engine graphics. The Onyx2 could do several full 720x486 resolution flipbooks without slowing down because of its very good I/O capabilities. For my home computer, I generally stuck with one flipbook at a time, which was fine with its Ultra2 SCSI drive, but Shake still had no trouble playing a couple of flipbooks simultaneously.

Shake 2.2 supports multithreading and will soon support up to eight processors, making it the fastest compositor on the planet. Really. Some compositing people use Shake in place of a Discreet flame* system or use Shake alongside dedicated nonlinear editors.

**FIGURE 1. Shake2.2 offers speedy rendering, improved timeline controls, better file-management tools, and drag-and-drop convenience.**

**Blurring Reality** The next thing that sets Shake apart is its inherent use of blur. All the transform nodes give you a parameter for motion blur, and you can select the type of filter you prefer the blur operator to use. As you know, live-action footage always has some blur in action sequences, and Shake incorporates this effect throughout the program. Version 2.2 has improved blur quality, as well as render speed.

A cool new feature lets you add motion blur to Shake's QuickShape utility. QuickShape allows you to draw mattes with a curve tool to use as garbage mattes or traveling mattes. The resulting mask can be controlled with a transform node or animated with points or tangents that define its shape. Adding motion blur to this will soften the edges of the matte to precisely blend in the foreground elements with background plates.

Shake also lets you reference motion from another element, say a Move2D node, and use its keyframed animation (rotations, pans, zooms) to add motion blur to computer-generated animation sequences. The documentation outlines this, using a pendulum as an example. You use the rotation values by putting the center of the rotation at the top of the pendulum, keyframe the Z angle to match the motion, then simply click the useReference option and set motion blur to a value above zero. Avoiding your 3D app's motion blur option saves you some valuable rendering time, plus it gives you more control over the final image by Shaking it.

**Nodes & Noodles** Shake 2.2's GUI looks more organic than apps that use a tree to represent files and processing nodes (Figure 1). Buttons look like they squish in and out when toggled. Images and sequences are loaded through the FileIn nodes composited with color-correction nodes, keying nodes, layering nodes, and transform nodes along

with other nodes such as Deinterlace. These nodes connect to each other with flexible curved lines that Nothing Real calls *noodles*. You edit intuitively by attaching nodes to the tree and by using your noodle to route inputs and outputs between nodes (Figure 2).

The interface is divided into four screens: the viewer, node window, tweaking window with each node's parameters (Figure 3), and function window with tabs for FileIn, Color, Transformation, Layer, Keying, and custom macros that you can make in the handy GUI tool, Macro Maker.

The interface has some similarities to Alias|Wavefront Maya. For instance, hitting the space bar will pop up whichever window is currently in use to full-screen mode. Panning the view in a window is done by holding down the Alt key and dragging, or just dragging with the middle mouse button. Zooming is done by holding down Alt and dragging with the first and middle mouse buttons. You can also drag and drop expressions and values into other parameters.

Once you're ready to render, attach a FileOut node—as many as you like. You might attach output nodes for film, D1, and JPEG formats all at the same time. With Shake you can also mix renders on NT, IRIX, and Linux.

**GUI or No GUI?** Shake allows you to work whichever way suits you. If you aren't adept at typing strings of code, then the GUI will do almost everything you will ever need. If you're able to hack out UNIX scripts to perform repetitive tasks, then you'll like the functionality of the command-line shell and the ability to run scripts for batch renders.

Use the command line for mundane tasks including rotating, scaling, and changing formats. It's easier and quicker than cranking up the GUI, particularly when working with large compositing scripts. Programmers will appreciate that they can use C language scripting to modify routines, and Shake will compile them itself.

By the way, you can download a .tcshrc UNIX shell at www.nothingreal.com. For those of us who grew up on UNIX and IRIX, this may offer some comfort. It lets you use UNIX shell commands on NT workstations.

**A Little CGI History** Shake's look and feel are influenced by the developers' experience in programming for a 3D animation software

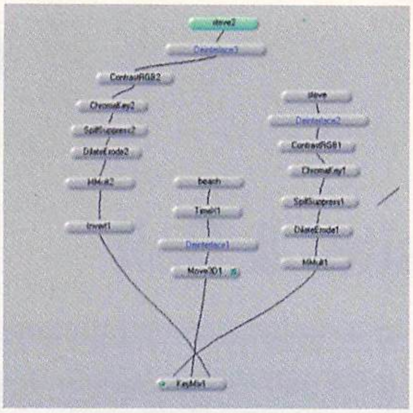

**FIGURE 2. You edit by attaching nodes to the tree and by using your noodle to route inputs and outputs between nodes.**

company, TDI (Thomson Digital Imaging, Paris, France), and for film production at such companies as Sony Pictures Imageworks and Square LA. Arnaud Hervas, chief technical officer of Nothing Real, wrote the IPR module for the once-famous animation package TDI Explore, which is the basis for Maya's IPR. Allen Edwards, president of Nothing Real, was also a former TDI guru who became a lead animator at Sony Imageworks before starting on Shake. Also worth mentioning is that Ron Brinkmann, Shake's product manager, wrote a great reference book called *The Art and Science of Digital Compositing* (Morgan Kaufmann, 1999).

Continuing the TDI thread, the old TDI image format is exactly the same as Shake's IFF format. Interestingly, Alias licenses IFF from Nothing Real for Maya. This makes Shake very well suited to support Maya by using the native IFF image format in textures and image mapping, which helps increase

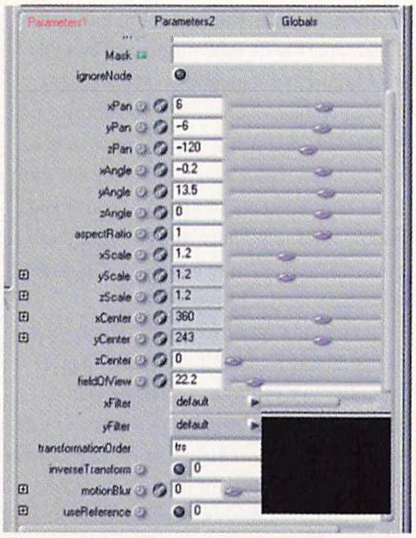


**FIGURE 3. The tweaking window lists each node's parameters.**

workflow efficiency.

If you're a Maya user, you probably use the utility fcheck also written by Arnaud. If you like the functionality of fcheck, you'll love the flipbook in Shake. The level of detail for the viewer display and the flipbook may be adjusted in the GUI interface's proxy settings.

**Shaken, Not Stirred** Lastly, the documentation is entertaining and thorough, with many tutorials to help you master Shake. All documentation is in HTML format and is updated regularly. To get a printed manual, download an Adobe PDF file at Nothing Real's web site and print it out. Customers are compensated for this arrangement by not having to pay sales tax.

For professional compositing, I know of no better software solution. Nothing Real's credits include such films as *The Matrix, Mission to Mars, Fight Club, Gladiators, Romeo Must Die, Nutty Professor 2, Anna and the King, Mission: Impossible 2,* and *The Road to Eldorado*. Its speed alone makes it a pleasure to work with. I would like to see a few minor additions that would make Shake an awesome nonlinear editor—transitions, grid-based warping, morphing, time editing, and an audio scratch track.

Some enhancements planned for future versions are procedural vector-based paint, enhanced color-correction tools, third-party plug-in support for The Foundry Tinder tools, Ultimatte, CFC Keylight, UniqueId Cakes, and new products featuring real-time 601 and HDTV I/O. Go to www.nothingreal.com and get it free for 15 days.

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## sources

**Shake 2.2** · **$9,900 for a network license**
**Nothing Real**
(310) 664-6152 · www.nothingreal.com

**SYSTEM REQUIREMENTS:**
**Windows NT 4.0, SGI IRIX 6.2 or later, Linux; OpenGL; 128MB RAM recommended**

BY RAF ANZOVIN

# Walkin' the Cat

## How to move an upright, knee-locking biped and make it look natural.

*Homo sapiens* enjoys the dubious distinction of being the only creature on earth with a vertical spine and locking knees. Given this odd anatomy, the strange and counterintuitive methods humans have devised for getting around without falling flat on their faces have caused animators no end of trouble (not the least of which is lower-back pain due to long nights in front of a monitor or light table). That's why mastering the simple mechanics of a walk—seemingly one of the easiest but in fact one of the subtlest and most difficult motions to get right—has always been the essential rite of passage for any journeyman animator, CG or traditional.

This month, we'll look at the construction of a basic bipedal walk cycle, appropriate for any cartoony character, human or otherwise.

There are two essential poses in a walk cycle. In the "strike pose" (Figure 1), the character's weight is evenly distributed between the front foot, which has just struck the ground, and the back foot, which is about to leave it. In the "passing pose" (Figure 2), the weight is balanced exactly over one foot while the other foot passes by off the ground. Transitioning between these two poses gives you the basic foot motion for a walk, but it takes much more work before the walk is convincing. Here are some points to keep in mind.

**FIGURE 1. In the strike pose, one of two basic poses in a walk, the character's weight is balanced 50/50 between the foot that's just touched the ground and the foot that's about to lift off.**

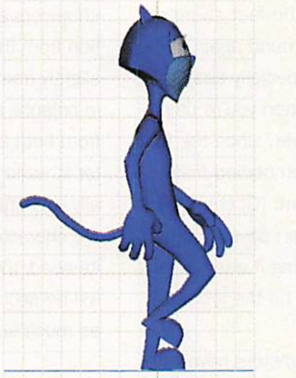


**FIGURE 2. The other basic walk pose is the passing pose, in which all the weight has shifted to one foot and the other is passing by it off the ground.**

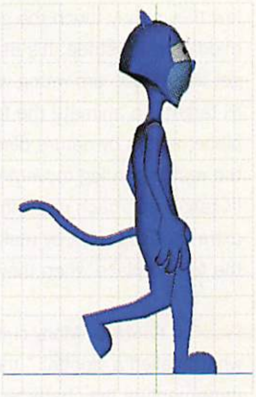


**FIGURE 3. The back foot must visibly push the character off the ground as it lifts off. This pose is two frames into the walk.**

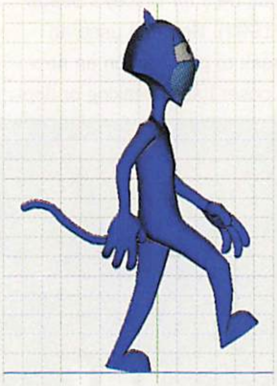


**FIGURE 4. Once the foot has passed in front of the character, it usually shoots out quickly to catch the character's weight. It may strike two or three frames before the body catches up.**

**FIGURE 5. Moving the foot in a direct arc results in something that looks like a march or goose step—not usually what you want in a walk.**

**FIGURE 6. The path of a real foot is more saddle-shaped, as the foot swings from the hip like a pendulum.**

**Push Off** Note that the foot leaving the ground isn't just moving upwards—it's pushing off. Usually, the first thing I do with that foot is push it to an extreme angle with the tip of the toe on the ground or slightly above, two or three frames after the strike pose (Figure 3). The pelvis needs to be pushed forward by the foot's movement to make the walk convincing, but usually not on the same frame. If the pelvis twists forward at the same time the foot does, it will usually just look like a distracting jump. The pelvis twists a few frames later, after the force resulting from pushing off the ground has propagated up the leg.

**Foot Strike** Since walking is controlled falling, the name of the game is getting the striking (front) foot out in front of the character quickly enough to keep it from falling too far forward. So the striking foot usually flips out toward its goal quickly, once it's out of the balanced-on-one-foot passing pose, and may get there a few frames ahead of the body. That gives the animator an opportunity to create a character-defining "pre-strike" pose as the front foot is about to strike the ground (Figure 4). Art Babbit, one of Disney's master animators, often used this moment to add little flourishes to the walks of his characters. For example, Babbit would make Goofy stick his feet out sideways just before hitting the strike pose.

**Feet in the Saddle** One of the common beginner's mistakes is to make the feet move in a smooth parabolic arc—up from the ground, into the air, and back down (Figure 5). This looks like marching or goose-stepping—perhaps the desired effect for some characters but usually not the right

kind of walk. Normally, the foot's motion path is more a saddle shape than a parabola (Figure 6), because as long as the feet are in the air they actually swing from the hip like a pendulum. In many walks, the feet swing so low they nearly touch the ground again in the middle of the stride. It's especially easy to get the motion arc wrong when you're using IK targets to animate the feet, since the foot placement is by nature disembodied from the rest of the leg movement. (Of course, the IK target approach more than pays for any extra arc-fixup work by making it easy to lock the feet in place when they hit the ground.)

**Freefall Footfall** Many characters have what's called a "footfall," the dip in the pelvis movement as the character brings itself to a stop and starts on the next step. Heavy characters usually pause perceptibly between steps, as they absorb the impact from the previous step and work up the energy needed to move their bulk forward for the next. Huge characters can have tremendous footfalls that last for a step or longer, complete with secondary action on blubbery bellies. Lighter characters may have barely noticeable footfalls that help convey a minimal sense of weight.

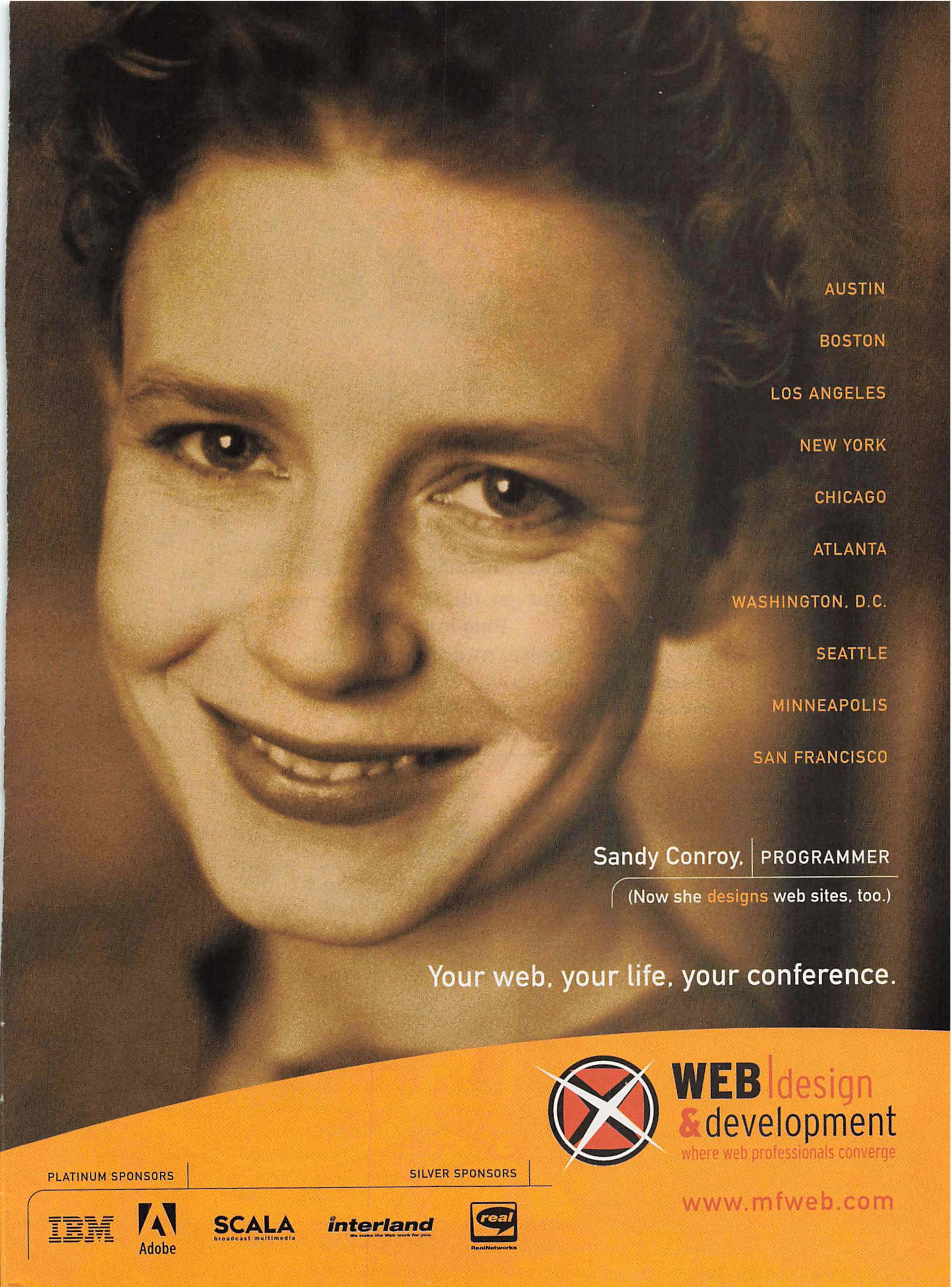
**Do the Twist** The pelvis twists in alignment with the striking leg, but the upper spine and shoulders always twist in the opposite direction from the pelvis. The spine also twists slightly from side to side to keep the character in balance as it switches its center of gravity from both feet to only one. When the character is walking with a straight back, there's usually very little forward and back movement. If the character is slumping forward and hanging its head, then most of the spine movement will be secondary up and down motion without as much shoulder twisting.

**Arm Breaks** Arms always hit their poses before the feet, usually while the feet are still in the passing pose. Hands and fingers often have secondary action applied to them as the feet catch up to where the hands are; a slight snapping movement is often used. An interesting example is Gaston's walk, animated by Andreas Deja for Disney's *Beauty and the Beast* (1991). He often used an extreme arm break to give Gaston an arrogant swagger. Looser hand breaking or flopping can be used to make a character look gangly, goofy, or drunk. A slight head bob can be added a couple of frames after the striking heel hits the ground, allowing time for the small shock of impact to travel up the spine.

**Walking in Context** Of course, getting the walk mechanics right is only the beginning. The walk must also reflect a wide variety of other factors, notably the physical environment, the emotional state of the character, and the dramatic situation of the scene. Moreover, you often mix the walk with other forms of motion, such as talking, gesticulating, or running. (Runs are an entirely different area of study—a run is really a series of jumps—but in many situations it's necessary to combine what is basically a fast walk with small jumps/run cycles.)

Next month, we'll look at issues involved in animating characters that are both bipedal and quadrupedal.

**Raf Anzovin is the cofounder of Anzovin Studio, a character-animation house based in Amherst, MA. Contact him at raf@anzovin.com.**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BY ALEX LINDSAY

# Don't Model It—Just Map It

**Digital matte paintings can save you tons of time when creating CG backgrounds.**

I have some good news and some bad news for you. I'll start with the bad news—if you've been building 3D environments with lots of geometry and texture maps, you've probably been working way, way, way too hard. The good news is that I have a few tips that could dramatically improve the speed and efficiency of your entire workflow.

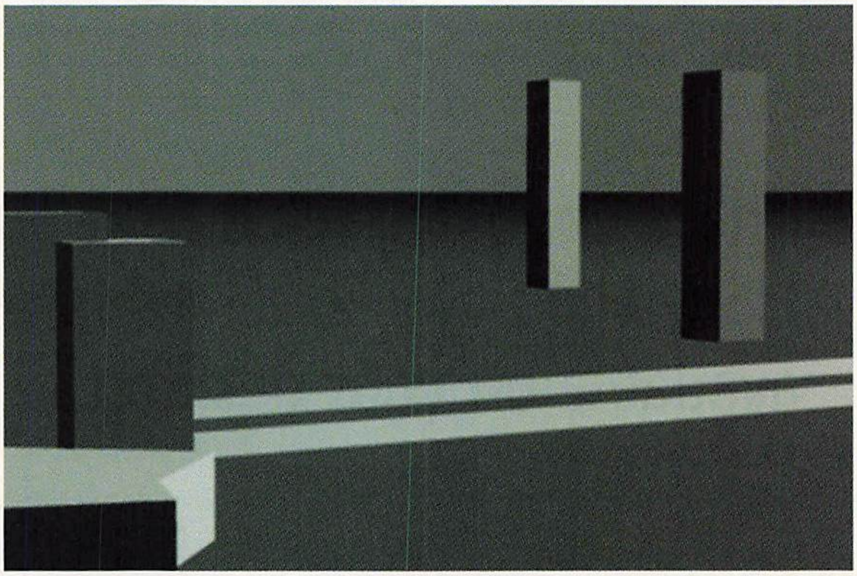
Most of us trained in the traditional forms of 3D animation think of an environment as a group of individual objects. I propose that you begin to think of these environments as a whole instead. When you think of texture maps, I invite you to think of texture mapping the entire environment all at the same time, not just each individual object.

On the surface, it all seems somewhat insane. How could I texture map everything all at the same time? I'm referring to the creation of 3D digital matte paintings.

Matte paintings have been around for hundreds of years. In their most rudimentary incarnation, they were simply the paintings that sat outside the windows on a stage set. As we entered the film era, these paintings were used at the edges of the film set. Slowly, artists achieved the ability to composite these paintings (after shooting the principal subjects) into the scene. Typically, an artist painted a very large pane of glass to act as a set extension for a feature film. In the early '90s, some visual effects companies began to use Adobe Photoshop and similar applications to create these panes via computer.

We have now moved to the next step of this evolution, where we're no longer simply putting 2D panes behind our foreground scenes. We're actually moving into and interacting with our painted environments.

Projected 3D digital matte paintings typically start with a series of photographs, a talented 2D artist, or both. One of the keys to making this science work is understanding how little a camera moves in a typical shot.



**Top: A 2½D scene of New York City (photo supplied by Photodisc). Bottom: Here's the extremely complicated (ha!) geometry.**

For many shots, we rarely see our environment from every possible angle. In fact, we usually see only a few degrees. So why build the entire city? Why not just paint what you'll see? This is how 3D digital mattes work. This is not unusual, by the way. We work in an industry where a typical set extends only a few feet beyond the camera view.

Normally, we project texture maps orthographically onto one object at a time. With image-projection mapping, we project a single image from the point of view of the camera across groups of objects set to receive the image. One important factor here is that the projection takes into account the distortion introduced by the field of view of the virtual camera. This is an important distinction because simple projection lights usually don't allow you to make this adjustment. Without this ability you can't match a real

camera source or match a simple snapshot from the application.

This is a godsend for matte painters who don't need or want to create every angle of a scene. They only need to create a given view. For the matte painter, the first step is to lay out a rough set of primitive objects to define the placement of buildings or other significant features. Next, take a snapshot from the virtual camera and bring it into Photoshop. You can then simply paint over the layout. Once projected from the camera onto the scene, the image will "stick" to the layout, providing the appropriate parallax. Obviously, two or more separate images are often necessary as you will be revealing the background when the camera moves forward.

The second method starts with a photograph. This provides a great opportunity to create establishing shots from simple photographs. The first step is to match the camera focal length and position, so you have the same vanishing points in the photograph and the virtual world. Once this is established, you can insert simple cubes and planes to match the elements in the photo. As with the matte painting, more than one image is often necessary to give the scene something to reveal as the camera translates. Inserting objects for photographic elements is only necessary with the most prominent objects, but the more you add, the better it looks.

There are a few programs that currently allow you to create this effect. NewTek LightWave, Alias|Wavefront TiPiT (a Maya plug-in developed by Hitachi), MetaCreations Canoma, and Play Electric Image are the most prominent. Of these, Electric Image has been used most frequently; EI's camera mapping has been used in *Mission: Impossible*, *101 Dalmatians*, *Spawn*, *Star Wars Episode 1: The Phantom Menace*, and many others.

There are proprietary and research versions of this method out there. Paul Debevec from the University of California at Berkeley (fiatlux.berkeley.edu) is one the leaders in this area. His work has been featured at SIGGRAPH, and a derivative of his work was used in *The Matrix*.

Don't consider this just a neat trick. It's truly the state of the art in digital matte creation. On top of being great for feature films, it's an excellent way to impress clients, for their heads will spin as they try to figure out how you re-created New York City in a week. Best of all, it's actually easier than the old way, not harder.

**top 5 camera mapping tips**

1. Remember, you can use **more than one image**, which can give you much more flexibility in your shot.
2. Spend the time to **carefully line up your shot with your geometry**. If you move through this phase too quickly, you'll find the map slipping... or worse.
3. Stop thinking in 3D or 2D and **start thinking in 2½D**. Look at where you can cheat: What will you actually see?
4. Keep track of your **camera information** (focal length, position, etc.). It makes the process much easier to set up.
5. Have **objects interact** with your new environments. Reflections and shadows go a long way toward selling your illusion.

**Since finishing work on *Star Wars Episode 1: The Phantom Menace*, Alex Lindsay has founded the DV Garage, a company dedicated to empowering people to express themselves through digital media. He can be reached at ablindsay@dvgarage.com.**

# EDITORIAL resources

**3Dlabs**
Oxygen VX1, Oxygen GVX210
www.3dlabs.com

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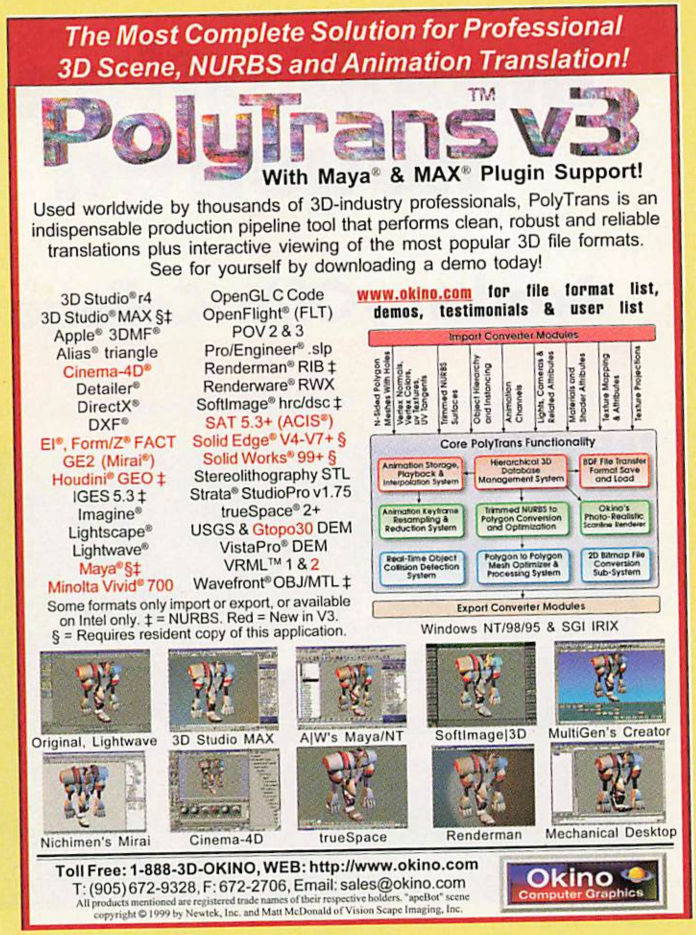
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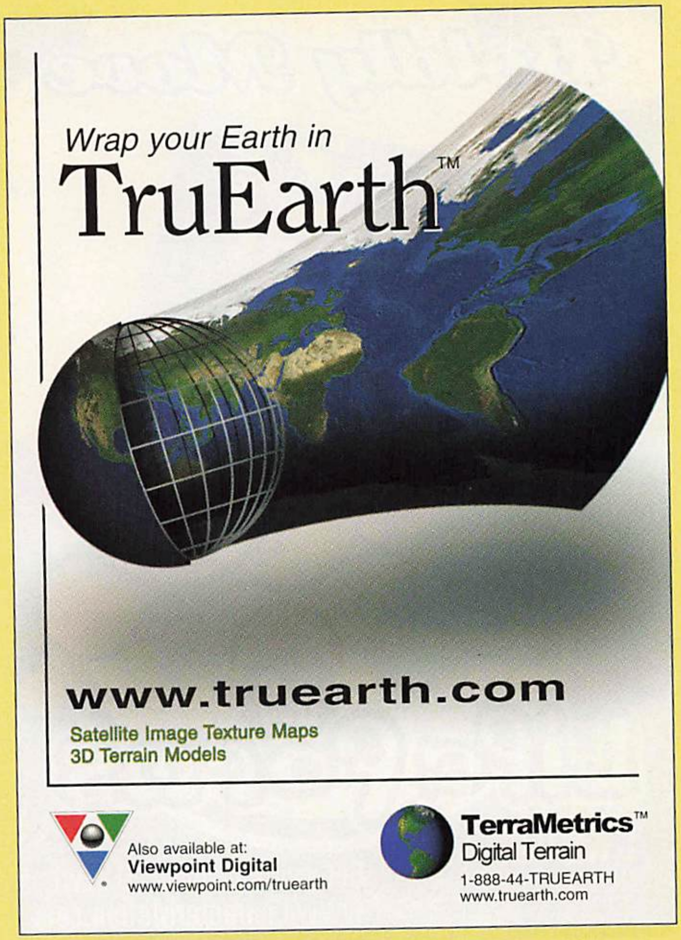
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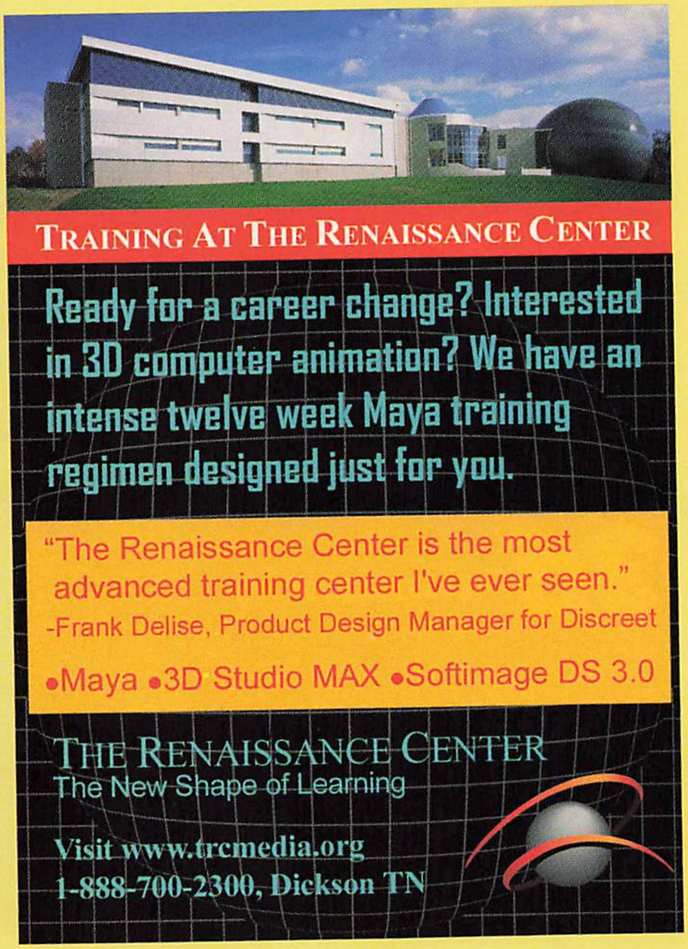
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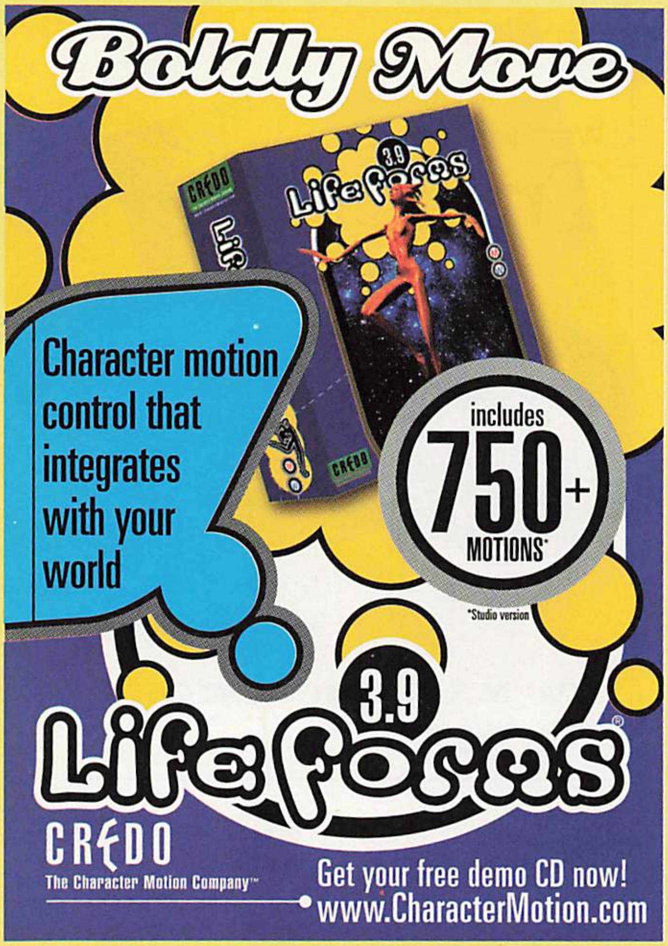
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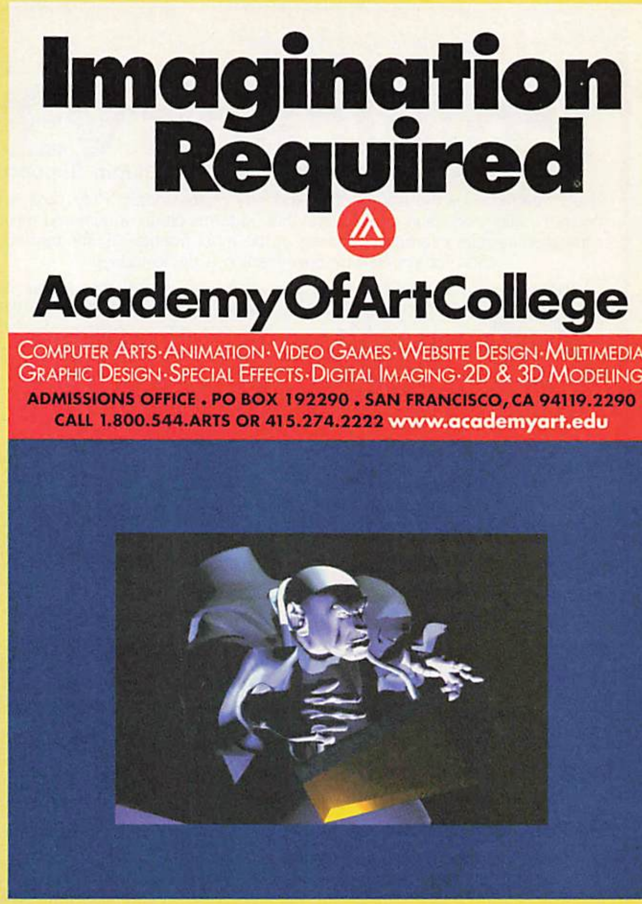
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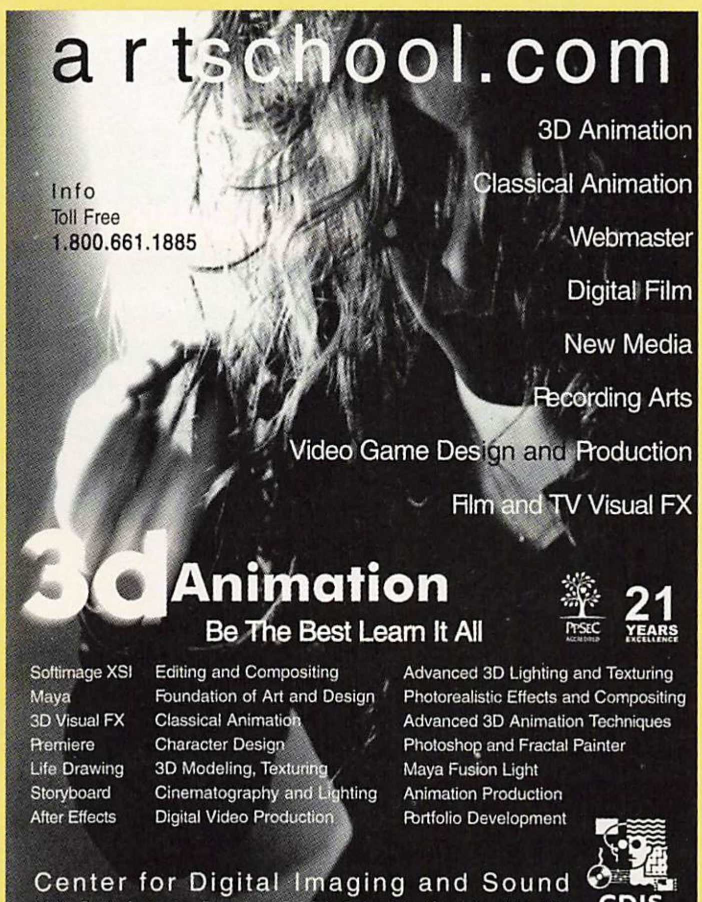
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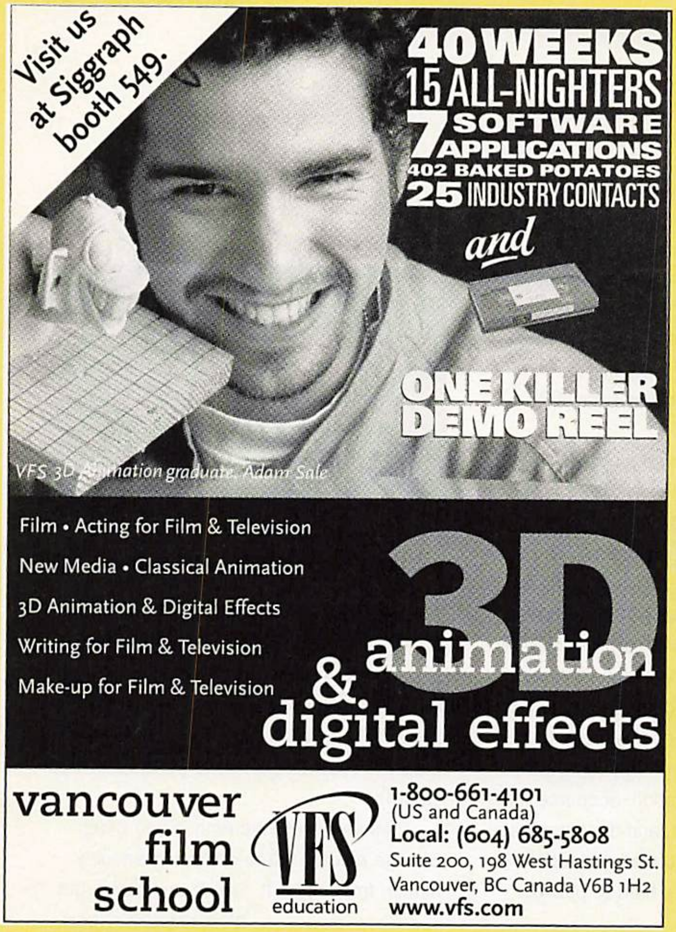
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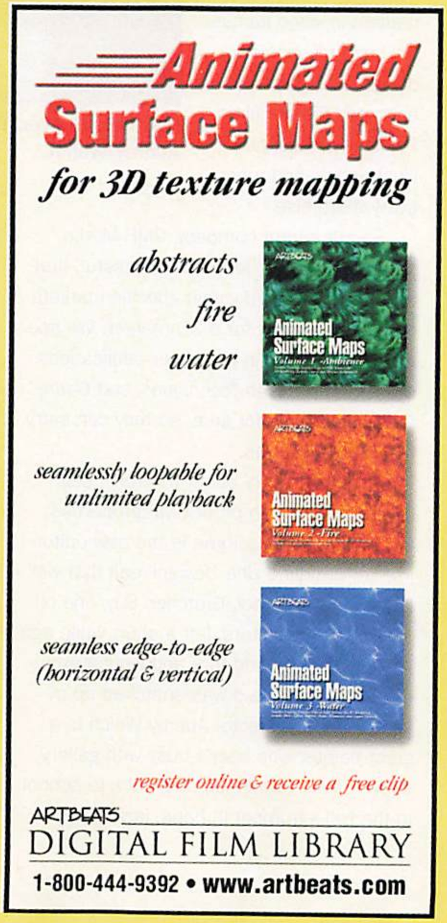
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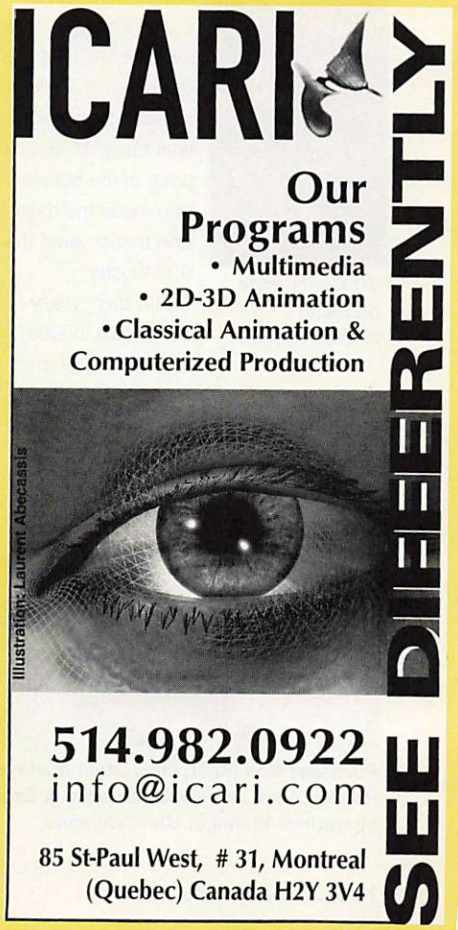
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BY MATTHEW HOOVER

# The End (Really)

**The debut issue of *3D Design* included a roundup of current graphics cards. You could get a nonupgradable PCI board based on 3Dlabs' GLINT 300SX processor, with a whole 4MB VRAM *and* 8MB DRAM, for just under three thousand bucks. That was late 1995.**

Your three grand will get you a bit more technology today, to say the least. The most dated computer in your studio probably has more graphics memory than that. (No, wait, I take that back—I've seen some of your studios.)

**Tech editor and general trouble-maker Chris Tome, with East Coast sales rep Kim Dusel.**

3D graphics have come a long way since our premier issue. It's proliferated beyond the "3D market," whatever that was, into specific areas where the technology is useful—digital video, game development, visualization, simulation, and of course the Web.

**3D Conference manager Andrea Moore.**

We learned just as we were finishing this issue that it would be our last. Here's some final thoughts and pictures of the people who made the magazine that covered the 3D industry.

But there really isn't a "3D industry," so to speak. There's certainly still a booming "computer graphics" industry, including plenty of subindustries, and 3D ripples throughout it. When 3D technology first became feasible on a PC, some visionaries assumed all things computer-related would be three dimensional in the near future—say, the late '90s—and the "3D industry" would be growing for years.

**Publisher Bob Melk, circulation manager Ron Escobar, and 3D Conference & Expo operations manager Gia Carunchio.**

Well, that has happened. And it hasn't. 3D technology has certainly spread far and wide—from Hollywood animation to garage animation, special effects, training and simulations, data visualization, of course the Internet, and the list goes on. But what 3D hasn't done is remain its own isolated industry. It's hard to put your finger on "the 3D industry" because it's so decentralized now. 3D is present in video games, CAD and mechanical design, web graphics, animated feature films, TV commercials, print illustrations, and most everywhere else.

**Matthew Hoover, Ted Greenwald, and Audrey Welch.**

So our parent company, CMP Media, says that 3D has been so successful, that it's best addressed within specific markets instead of looking for a 3D market. We see lots of 3D action in our sister publications *CADENCE*, *DV*, *Web Techniques*, and *Game Developer*, that's for sure, so they can carry the 3D torch for us.

And don't worry about us. You'll see plenty of staff with other CMP properties, including *DV*. Chris Tome is the new editor-in-chief of online zine DesignFreak that will launch this summer. Gretchen Bay, one of *3D*'s founding editors, left a short while ago for a year-long world tour and writing excursion. Ted Greenwald was snatched up by *Wired*. Our art director Audrey Welch is a great painter who keeps busy with gallery shows. Mike Kobrin is going back to school in the Fall—trumpet in hand, jazz in head.

**Mike Kobrin and Gretchen Bay—GJB was here since the launch of *3D* and is now traveling the world.**

And I'm leaving in July for my first bicycle tour—three months and however many miles I feel like doing across the USA. The low-tech life is calling me for a little while, before I return to the Bay Area and its wired lifestyle.

Change is not inherently a bad thing. Change reveals future options previously hidden from sight. It can be unsettling, but it's a necessary part of growth, improvement, and life in general. You have exponentially more paths ahead of you if you embrace change and all the possibilities it opens up. It's your world—fight like hell to make it what you want.

**Carole Langston, Peter Young, Mike Kobrin, Matthew Hoover, Johanna Kleppe, Stacey Ackerman, Holly Nelson, Kim Dusel, Nicole Garbolino, Kerry McKee, Michelle Gorsuch, Dr. McCoy, Kathleen Sachs, Bob Melk, Andrea Moore, Michelle Stutsman, and Jill Perretti wish you the best!**

**Postal and Rates** *3D* (ISSN 1526-0720) is published monthly by Miller Freeman Inc., a member of the United Newspapers Group, 600 Harrison St., San Francisco, CA 94107, (415) 905-2200. Domestic subscription rate for one year is $29.95. Canada/Mexico $39.95. All other foreign $69.95 (via airmail). Back issue price is $9.00 (domestic and foreign).  Periodicals postage is paid at San Francisco, CA and additional mailing offices. **Postmaster:** Send address changes to: *3D*, Circulation Dept., PO Box 5031, Brentwood, TN 37204-5301. Thanks for the memories...